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MOSQUITOES OF THE NORTHWESTERN STATES

By

H. H. STAGE, C. M. GJULLIN
and
W. W. YATES, Entomologists

Division of Insects Affecting Man and Animals
Bureau of Entomology and Plant Quarantine
Agricultural Research Administration

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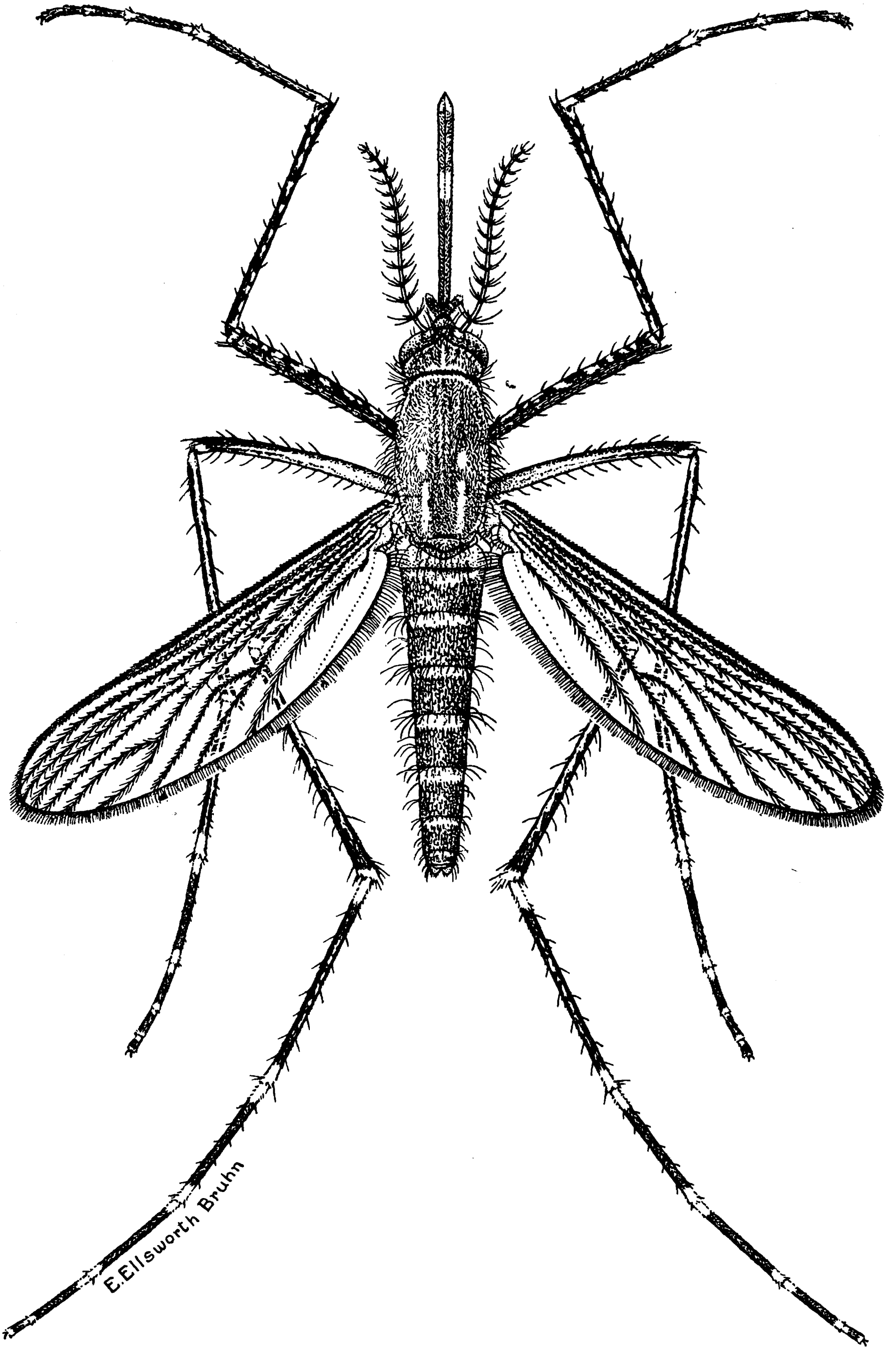
This handbook deals with the mosquitoes recorded from the three Northwestern States—Oregon, Washington, and Idaho. It brings together widely scattered information on 39 species and subspecies, including descriptions and keys for identifying the species and notes on the several associations of species and their biology, their economic importance, distribution, and methods of control. The handbook has been prepared as a companion to Miscellaneous Publication 336, The Mosquitoes of the Southeastern States (*83*). The control methods recommended here differ considerably from those in that publication because many new insecticides have been developed since it was last revised.



Culex tarsalis, the most widely distributed mosquito in the Northwest. It breeds in the widest variety of waters and is one of the most potent transmitters of western equine encephalomyelitis and St. Louis encephalitis.

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[1] Grateful acknowledgement is made of the aid given by E. F. Knipling, who was in charge of mosquito investigations in the Pacific Northwest from August 1, 1940, until April 1, 1942, and who later, as chief of the Division, gave invaluable council. Thanks are due also for data contributed by A. W. Lindquist, R. A. Hoffman, and A. R. Roth, of the Corvallis, Oreg., laboratory.

MOSQUITO LITERATURE

THE literature on mosquitoes has become exceedingly large. Each year about 1,000 references to various phases of mosquito biology and the diseases they carry appear in widely scattered publications. Probably no other group of insects has received so much study throughout the world. Some of the publications of especial interest to workers concerned with mosquitoes in the Northwest are given at the end of this handbook (p. 87).

One of the earliest comprehensive works on any group of insects is a four-volume monograph by Howard, Dyar, and Knab (*68*), issued in 1912-17. It includes descriptions, biology, distribution, and taxonomy of mosquitoes in the Western Hemisphere north of the equator.

Matheson's handbook (*99*), revised in 1944, gives much information on the taxonomy and biology of the mosquitoes of North America and includes a discussion of their relation to human welfare and problems of control.

More recently, in 1949, Carpenter, Middlekauff, and Chamberlin (*13*) published an authoritative book of nearly 300 pages covering the taxonomy and biology of species found in the Southern States east of the Mississippi River.

In another book that appeared in 1949, Marston Bates (*17*) has compiled a voluminous array of facts on the biology and disease relationships of mosquitoes, which will be very valuable to all students specializing in mosquito research and control.

A textbook by Herms and Gray (*62*) is designed primarily for entomologists, engineers, and staff employees who are directing the activities of mosquito-abatement districts. It gives information on laws and agencies for mosquito abatement, education of the public, general principles of abatement methods and techniques, abatement of disease vectors, and a host of related data.

The Engineering News Record (*25*) has issued a series of short papers on the engineering aspects of mosquito control.

For those concerned with the manipulation of water levels in the control of malaria and mosquitoes, a publication by the United States Public Health Service and the Tennessee Valley Authority (*162*) is indispensable. Although the information is focused on malaria control, the possible field of application is far broader as it may be of great use in the development of water resources, power, and irrigations in the Northwest.

Several State bulletins and a Canadian report will be found particularly useful in a study of the mosquitoes in the Northwest: California, by Freeborn and Bohart (*30*); Montana, by Mail (*97*); Utah, by Rees (*111*); Oregon, by Yates, Lindquist, and Mote (*174*); the Lower Fraser Valley of British Columbia, by Hearle (*58*). A guide for identifying mosquitoes of the Pacific Coast States, by Freeborn and Brookman (*31*), contains unique but valuable keys.

The following serial publications will be of interest to students of Culicidae: Mosquito News, published quarterly by the American Mosquito Control Association at Albany, N. Y., and the proceedings published each year by the New Jersey Mosquito Extermination Association, the California Mosquito Control Association, the Florida Anti-Mosquito Association, and the Utah Mosquito Abatement Association.

Articles on mosquitoes also appear in bulletins and reports of the United States Public Health Service and in various entomological, medical, and other scientific journals throughout the world.

For a number of years articles on various phases of the biology and control of anopheline mosquitoes appeared in the Journal of the National Malaria Society. This society has now amalgamated with the American Society of Tropical Medicine to become the American Society of Tropical Medicine and Hygiene, and its journal includes papers on mosquitoes and their disease relationships.

MOSQUITO-CONTROL ASSOCIATIONS AND ABATEMENT DISTRICTS IN THE UNITED STATES

There are seven mosquito-control associations in the United States (*140*), as follows:

The New Jersey Extermination Association, organized in 1913.

The Florida Anti-Mosquito Association, organized in 1929.

The California Mosquito Control Association, organized in 1932.

The American Mosquito Control Association, Inc., organized in 1936.

The Virginia Mosquito Control Association, organized in 1947.

The Utah Mosquito Abatement Association, organized in 1947.

The Illinois Mosquito Control Association, organized in 1948.

Each of these associations holds annual meetings, and most of them publish their proceedings, which contain valuable contributions on mosquito biology and control.

The American Mosquito Control Association is international in scope and has a membership of about 1,000. It is a nonprofit technical and educational association of mosquito workers, composed of entomologists, sanitary engineers, control officials, medical personnel, and laymen who are charged with or are interested in mosquito control and related work. Annual meetings are held in various parts of the United States, usually conjointly with the State associations.

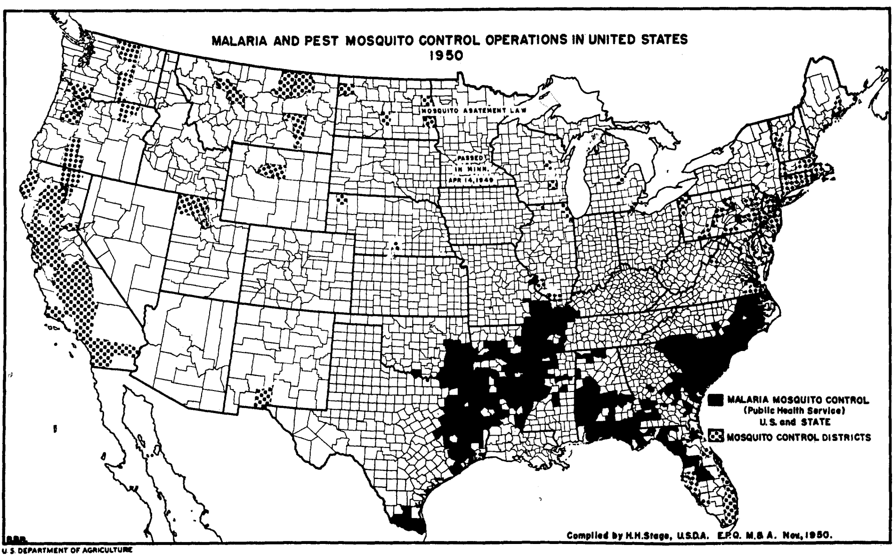


FIGURE 1.—Map of the United States showing location of mosquito-control operations, 1950.

There are about 250 local mosquito-control agencies in 39 States, Hawaii, and Puerto Rico (fig. 1). These agencies are commonly called mosquito-abatement districts and are usually named after the counties in which they are located. In 1951 Florida had 21 such districts, with a total budget of about $985,000; California 44, with over $1,700,000; New Jersey 16, with $640,000; Utah 4, with $117,000; Virginia 13, with $178,000; and Rhode Island 18, with $76,000. A total of more than $6,000,000 is budgeted annually in the fight against pest mosquitoes and malaria. Over 26,000,000 people in the United States live in areas protected from mosquito annoyance. During the last few years Federal and State health agencies have treated more than 800,000 homes with residual sprays annually for the control of malaria mosquitoes.

GENERAL CHARACTERISTICS AND HABITS OF MOSQUITOES

The characteristics and habits of mosquitoes in the Southeastern States as described by King and coworkers (*83*) apply generally to species found in the Northwestern States.

Although mosquitoes have extremely diverse breeding habits, particularly the type of place they select to lay their eggs, all have one important characteristic in common—they live part of their life in water and in water only. It may be in a small tin can or in a vast tidal marsh.

Some species are found throughout the Northwest and in different types of water. Others are found only in restricted areas and in one kind of water. For example, *Culex tarsalis* has been collected in almost every kind of water in nearly every county of the three States, whereas *Aedes hexodontus* is found only in snow water in high mountainous areas (*27*). Some genera, such as *Aedes,* lay their eggs on ground that may later be flooded, whereas others, such as *Culex* and *Culiseta,* lay them directly on the water surface.

Temperatures of air and water, alkalinity or acidity of the water, and associated shelter and vegetation affect the abundance and presence of most species. The species also differ in biting habits, longevity, and flight range.

The mosquito is an insect having a complete metamorphosis. There are four well-defined stages—the egg; the larva, sometimes called wiggler; the pupa or tumbler; and the adult or imago.

LIFE HISTORY

EGGS

The eggs may be laid singly as with the anophelines, or in rafts of about 150, as with the culicines. In very warm weather the eggs may hatch within 2 or 3 days after they are laid. In northern latitudes, however, eggs laid by *Aedes* in the late summer do not hatch until flooded the following spring. If not flooded the first season they may remain viable for several years (*45*). There is still some question as to whether northern *Aedes* eggs require a certain amount of drying and exposure to cold before they hatch or, as we believe, a low oxygen concentration (*40*). A blood meal has been considered necessary for the production of viable eggs (*70*), although among some of the northern *Aedes* this has not been definitely established.

LARVAE

All mosquitoes spend their larval and pupal stages in water, and most of them move freely about as aquatic insects. Without water these stages cannot survive more than a few hours. The larvae of most species must come to the water surface for air, which they obtain through an air tube or other appendage located at the end of the "tail." The larvae shed their skins four times, and each instar is larger than the last. The larval stage usually lasts from 4 days to 2 weeks; in icy-cold water some *Aedes* mosquitoes may remain as larvae for a month or more. The larvae of *Aedes varipalpus* occurring in tree holes and those of *Mansonia perturbans* attached to the roots of aquatic plants overwinter, and hence may exist as larvae several months.

The food of mosquito larvae consists of tiny plants, animals, and organic debris. Some species prey on the larvae of other species and some are cannabilistic. Barber (*6*) has reared larvae on pure cultures of various organisms, and Hinman (*63*) has suggested that materials in solution or colloidal suspension in the breeding water form a part of the larval food. We have reared large numbers of *Aedes vexans, sticticus,* and *hexodontus* in the laboratory on ground dog food and blood albumin. We have also reared *Culex quinquefasciatus* on yeast and powdered milk.

PUPAE

With the fourth larval molt the pupal stage appears. They move about by somersaulting. Except for *Mansonia,* a mosquito pupa's life is a short and active one. An excellent account of the emergence of an adult mosquito from the pupal stage is given by Marshall (*98*).

ADULTS

Only the female mosquito has mouth parts adapted for bloodsucking. While the insect is biting, it injects a secretion that is responsible for the itching that follows. Not all mosquitoes have bloodsucking females, but all those found in the Northwest do have.

The mouth parts of male mosquitoes are not strong enough for biting. Their food consists of pollen and of fruit and other plant juices. In the laboratory we have kept alive both sexes of some species for long periods on raisins, fruit juices, and sugar solutions.

LONGEVITY

The length of life of adult mosquitoes under natural conditions is difficult to determine, but for most of the northwestern species it is probably only a few weeks in spring and early summer. We have studied the longevity of *Aedes vexans* and *sticticus* by staining swarms of newly emerged adults in their breeding areas. One *vexans* female was taken after 55 days and one *sticticus* after 85 days. Six *sticticus* females were taken after 52 days and one *Aedes* male after 24 days (*147*). From these studies it appeared that longevity may depend somewhat on the time of the flood crest. Individuals hatching after a May flood lived longer than those that hatched after a late-June flood. Conditions of climate in the breeding areas probably exert the greatest influence on the life span. In one locality, for example, a *sticticus* male was captured 94 days and females of both species were collected 104 to (rarely) 113 days after emergence. The climatic and geographic factors in that locality were especially favorable —the humidity was high and the temperature comparatively low. The relative abundance of these species in the lower Columbia River valley in the years of high and low flood crest is given in figure 2.

FLIGHT

The distance that mosquitoes fly varies with the species and with the individual. Some individuals of *Aedes squamiger* may travel 60 to 70 miles, and those of *Culex pipiens* may remain within a few hundred yards of the place where they emerged as adults.

Sample collections and observations were made over several seasons. Some of our recorded data (*147*) on flight range (fig. 3) were obtained by staining and recovering adults. It was determined that *vexans* and *sticticus* of both sexes were dispersed in all directions, both within and

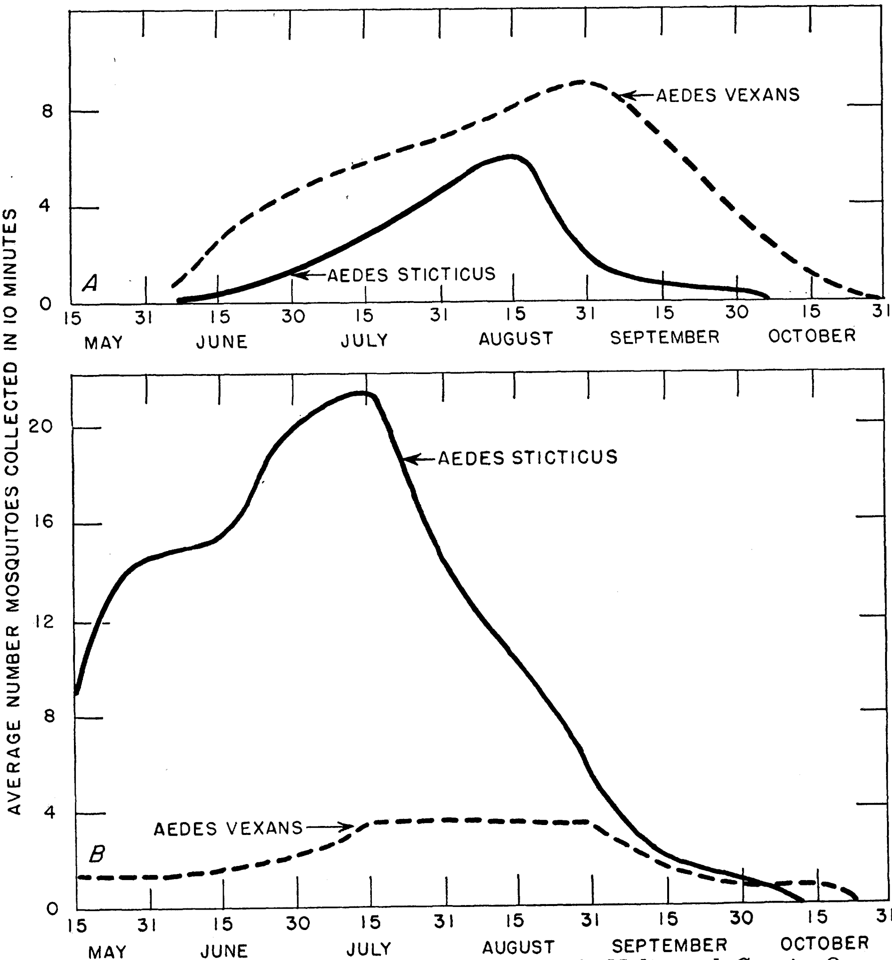


FIGURE 2.—Abundance of *Aedes vexans* and *sticticus* in Multnomah County, Oreg.: *A*, In the low-flood-crest years 1930 and 1931; *B*, in the high-flood-crest years 1932-1936.

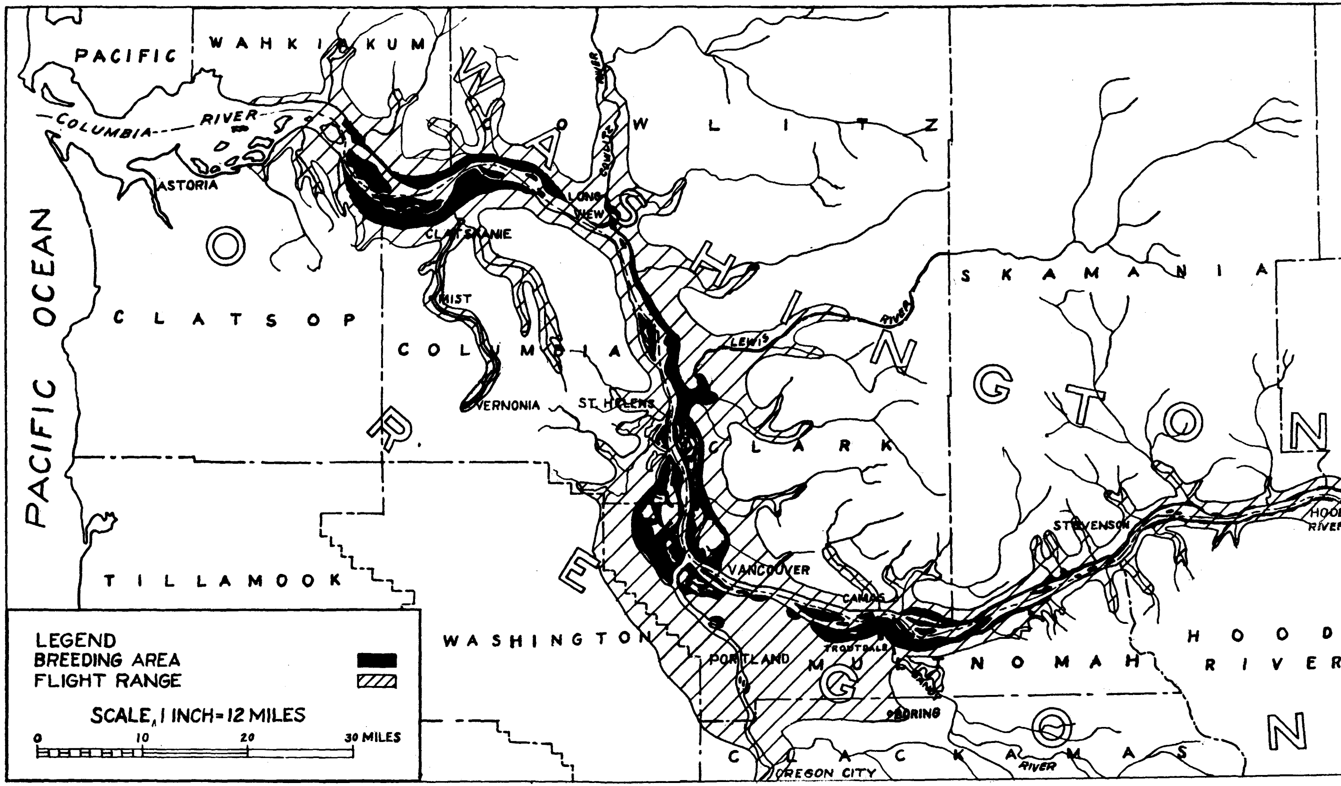


FIGURE 3.—Breeding areas and flight range of *Aedes vexans* and *sticticus* in the lower Columbia River Valley

against general wind currents, for a distance of 2 miles. Within 24 hours they traveled 5 miles, ½ mile of which was across the Columbia River. These staining tests were supplemented by observations made along a canyon road, through a heavily timbered section for a distance of 30 miles. For 15 miles *vexans* and *sticticus* were numerous, but 30 miles away only one female was taken in 10 minutes.

The size of the brood influences the distance that mosquitoes travel, but not their rate of travel. The height of the flood crest also affects the size of the broods. The greater the flood, the greater the radius of dispersion.

COLLECTION AND PRESERVATION OF SPECIMENS

A white-enamel dipper, the handle of which is lengthened with a cane or smooth stick, is the most convenient implement for collecting larvae (fig. 4). A little experience is necessary before one can dip successfully, because the larvae are frightened easily and may disappear below the surface of the water and out of range of the dipper.

FIGURE 4.—Using a long-handled dipper to collect mosquito larvae.

Upon reaching a spot to be sampled, especially if the water is more than a few inches deep, wait a full minute and then quickly skim the surface without allowing the water to flow over the edge of the dipper. Transfer the larvae from the dipper to a collecting jar with an eye dropper, the tip of which has been broken off to make an enlarged mouth.

As soon as a collection is made, number the jar and record the date, locality, and other pertinent conditions under which the larvae were found.

For easier identification place the larvae and pupae in shallow pans for rearing to the fourth instar, and then either preserve them in 70-percent alcohol or allow them to emerge as adults. Frequently several species may be taken in one dip. Therefore, select a few larvae and place them individually in small vials until the adults emerge. These adults can then be associated with their larval and pupal cast skins.

To make permanent slide mounts of the larvae, place them in 70-percent alcohol for a few minutes; then, pierce the larvae with a needle, place them in Cellosolve for a few minutes, and finally place the tissue to be preserved in balsam to harden. Mounts of the male genitalia can be made in a similar way.

A pillbox is convenient for holding or shipping specimens of adult mosquitoes. Place two pieces of soft tissue paper between two layers of cotton and the mosquitoes between the layers of tissue. Without the tissue paper the tarsal claws may cling to the strands of cotton and become broken when removed. Damaged, moistened, or rubbed specimens are usually unsatisfactory for identification.

Specimens of adults that are to be retained in permanent collections are best mounted on a minuten-pin stuck into a small square piece of cork, through which is passed a larger pin. Thrust the tip of the minuten-pin through the underside of the thorax of the mosquito, but not protruding through the mesonotum. The No. 3 entomological pin is generally the best size for holding the cork.

Label the mounted specimens carefully and pin them in a Schmitt insect box. Take care to protect the stored specimens from insect pests and dampness. Flake naphthalene or paradichlorobenzene placed in a perforated container and securely fastened in one corner of the Schmitt box will prevent damage from insect intruders. These insect repellents must be renewed occasionally.

IDENTIFICATION OF SPECIES

One must have a knowledge of mosquito anatomy to identify the different genera and species of mosquitoes. The principal distinguishing characters are the shape, size, coloration, and scaling of the different body parts.

A binocular dissecting microscope providing magnifications up to about 85× is necessary for satisfactory examination of the identifying characters.

For examining larval parts and slide mounts of male terminalia, a compound microscope having a magnification up to 400× is necessary. A bright spotlight is required when high magnifications are used.

In the field a good hand lens giving a magnification of 10 or 15× is satisfactory for provisional identifications. After some experience one will be able to identify some of the species in a given locality with a hand lens, or even with the naked eye.

Misidentification of mosquitoes may cause serious confusion. Inexperienced workers will find it helpful to have on hand for comparison a few specimens that have been correctly identified. Send specimens to a specialist with the request that they be named and returned. Identifications may be obtained through the Bureau of Entomology and Plant Quarantine and some of the State universities and agricultural experiment stations.

HISTORY OF MOSQUITO CONTROL IN THE NORTHWEST

The great numbers of mosquitoes appearing in the lower Columbia River Valley each May and June have been a serious problem ever since the first settlers reached there early in the nineteenth century. As the population increased there was much discussion of the annoying problem. It finally came to the attention of Oregon State College, and beginning about 1924, D. C. Mote, head of the Department of Entomology, was frequently consulted for advice and guidance. After surveying the situation and gathering the available information, in March 1926 he initiated the first effort at mosquito control in the Portland area by introducing mosquito fish (*Gambusia affinis*) from California. Mote's efforts led to organized action, and meetings were held in which leading citizens of Portland and Multnomah County took part.

Among the people who contributed to the movement was H. H. Riddell, an observing naturalist although not a trained scientist. Riddell became interested in mosquito control in Skamania County, Wash., about 1926, and by correspondence with H. G. Dyar, of the Smithsonian Institution, and others, discovered the breeding areas of the local species. Dyar had visited Oregon in 1916 and had made field observations of mosquito conditions which later were to have an important part in their control. In 1927 Riddell started mosquito control in a small way in Skamania County. He also met with the people of Portland and Multnomah County, and beginning in 1930 was in charge of the field operations of the Portland Chamber of Commerce Mosquito Control Committee. This committee was headed by Charles Stidd, and consisted of the entomologist of Oregon State College, representatives of Multnomah County and the city of Portland, certain recreational organizations—especially Jantzen's Beach—and was responsible for raising funds for the control program for more than 10 years.

In 1929 G. H. Bradley, of the Federal Bureau of Entomology, made a brief visit to the lower Columbia River Valley, collected some of the annoying mosquitoes, and made general recommendations which further stimulated interest in organized action.

Because little was known about the biology and habits of mosquitoes in this valley, the United States Department of Agriculture was asked to undertake a research program. In 1930 Congress appropriated funds for these investigations.

W. V. King, of the Bureau of Entomology, opened a laboratory in Portland in 1930, and spent 2 months surveying the lower Columbia River area and southeastern Oregon. He examined numerous breeding areas of the floodwater *Aedes* mosquitoes in several counties along the Columbia and Willamette Rivers and made hundreds of collections of these insects for identification. Aerial photographs of the overflow area in Multnomah County made under his direction were of great value in studies of the mosquito-breeding areas. The authors of this handbook conducted investigations from 1931 until 1940. Much of the information contained in it was obtained during those years, although additional data subsequently obtained by the junior authors are included.

In the winter of 1933-34 mosquito control in both Oregon and Washington was greatly accelerated through an allotment of funds by the Civil Works Administration (*129, 130, 132*). This work was conducted in Multnomah, Columbia, and Tillamook Counties in Oregon and in Kitsap, Skamania, and Clark Counties in Washington. Practical mosquito-control measures are being continued in the vicinity of Multnomah and Clark Counties, in which Dorothy McCollough Lee, Mayor of Portland, has been an active leader.

An enabling act for the organization of mosquito-abatement districts in Oregon was passed by the State Legislature in 1940.

GENERA AND SPECIES FOUND IN THE NORTHWEST

The mosquitoes found in the Northwestern States, their distribution and economic importance as recorded during the years 1930-51, are listed in table 1. Their distribution is shown in the maps at the back of this handbook. In addition to the 39 species listed, several more have been reported from the region, but the records are either obscure

TABLE 1.—*Species of mosquitoes occurring in the Northwestern States and their relative importance*[1]

Species	Oregon	Washington	Idaho
Aedes:			
aboriginis	4	2	5
campestris	5	5	0
canadensis	5	4	2
cataphylla	5	5	5
cinereus	3	2	2
communis	2	2	4
dorsalis	1	1	1
excrucians	3	4	3
fitchii	2	2	2
flavescens	4	4	4
hexodontus	2	2	5
idahoensis	5	5	4
impiger	0	5	5
increpitus	1	2	1
intrudens	5	4	4
nearcticus	4	4	5
nigromaculis	4	4	1
niphadopsis	5	0	4
pionips	0	0	5
pullatus	5	4	4
sticticus	1	1	4
trichurus	0	5	4
varipalpus	4	4	0
ventrovittis	0	5	5
vexans	1	1	1
Anopheles:			
freeborni	1	1	1
occidentalis	5	5	5
pseudopunctipennis franciscanus	5	0	0
punctipennis	2	2	4
Culex:			
pipiens	4	4	5
stigmatosoma	4	4	0
tarsalis	1	1	1
territans	3	3	3
Culiseta:			
impatiens	4	4	5
incidens	1	1	3
inornata	1	1	1
maccrackenae	5	0	0
morsitans	5	5	0
Mansonia:			
perturbans	4	5	5

[1] 1, Most important because of abundance, wide distribution and economic significance; serious pests or disease carriers. 2, Abundant under restricted ecological conditions. 3, Widely distributed, but not in large numbers. 4, Abundant but important in only a few isolated areas. 5, Rare species.

or the species were confused with valid forms. Some of the information presented in this paper was obtained from records in the literature, principally from the comprehensive works of Dyar (*22, 23*) and Howard, Dyar, and Knab (*68*); also from collections in the National Museum, Oregon State College, Washington State College, Idaho State College, and the U. S. Public Health Service.

The Northwestern States do not have a large number of species, but in certain localities the prodigious numbers of some of the *Aedes* mosquitoes have seriously affected economic enterprises. The following species are of greatest economic importance:

Anopheles freeborni (*2*) occurs in great numbers in the irrigated valleys of Washington and Oregon. It has been the most important vector of malaria in the region.

Aedes dorsalis breeds in saline, alkaline, or fresh irrigation water. It is abundant in the salt marshes, and in certain areas is a great handicap to the dairy industry. The viruses of western equine encephalomyelitis and St. Louis encephalitis have been isolated from it in nature.

Aedes increpitus is a severe biter, and in high elevations is one of the most annoying species to man and animals.

Aedes hexodontus is very numerous and annoying in restricted mountainous areas.

Aedes sticticus breeds in large numbers in the willow flats along the lower Columbia River, and is a severe biter of man and livestock.

Aedes communis occurs in mountainous areas, and in some places is a very serious hazard to recreational interests, lumbering, and road building.

Aedes vexans is one of the most troublesome pest species in both irrigated and floodwater areas, and is found near sea level and also in mountain meadows. The adults disperse for 10 to 20 miles from their breeding places and are severely annoying to man and livestock for 3 or 4 months each year.

Culex pipiens occasionally is extremely numerous and annoying in communities in the western portion of the Northwest. It seldom occurs in Idaho or the eastern half of Oregon and Washington.

Culex tarsalis (see frontispiece) is one of the most widely distributed mosquitoes in the region. The larvae have been taken from rain barrels, log ponds, stagnant pools, sluggish streams, woodland ponds, and alkaline sumps. They have not been found at high elevations or in salt marshes. Although they prefer to feed on fowls and livestock, they will readily attack man. Viruses of both western equine encephalomyelitis and St. Louis encephalitis have been isolated from collections of this species in several States, and transmission of these viruses to chickens and ducks has been demonstrated.

Culiseta inornata, an important livestock pest, annoys humans very little.

MOSQUITOES AND DISEASE

MALARIA

We are not sure when malaria first appeared in the Northwest, since our sources of information do not agree (*21, 90, 125, 163*), but it was probably about 1830. However, they all show the important bearing of the disease on the early history of the region—its fatal character and that great numbers of the native population died because of it. Neither do we know how it reached the Northwest, but as one author (*125*) aptly describes it, it was most likely "dragged across the plains" by parties from the East and South that assembled at Independence, Mo., for their long journey into the Oregon Territory. It may also have been brought in by sailors and travelers who had come from malaria belts in the United States or who had touched at Central American ports before reaching the Northwest.

Malaria was first required to be reported to the State health officer of Washington in 1915, and of Oregon in 1918. Figure 5 shows the cases of malaria reported in Oregon for the period 1920-44. During the years 1945-

47 a considerable increase in this disease was reported, but most of the cases originated outside the United States. Since then only two cases have been reported as originating within the State, one in 1948 and one in 1950. Only rarely have any cases of malaria emanated from the State of Washington.

In Idaho it has been a reportable disease on a voluntary basis since 1936. Up until 1945 only 20 cases had been reported.

Anopheles freeborni, a vector of malaria, occurs widely throughout the Northwest (*43*), but breeds most profusely in the upper Willamette Valley of Oregon. The other species of *Anopheles* occurring there are probably of little significance as transmitters of the disease. The winter climate is similar to that of the northern range limits of the disease in the Mississippi Valley, although the mean winter temperature is slightly higher for Eugene, Oreg., than for Cardwell, Mo., where malaria has been very common. The summers, however, are much cooler in Oregon.

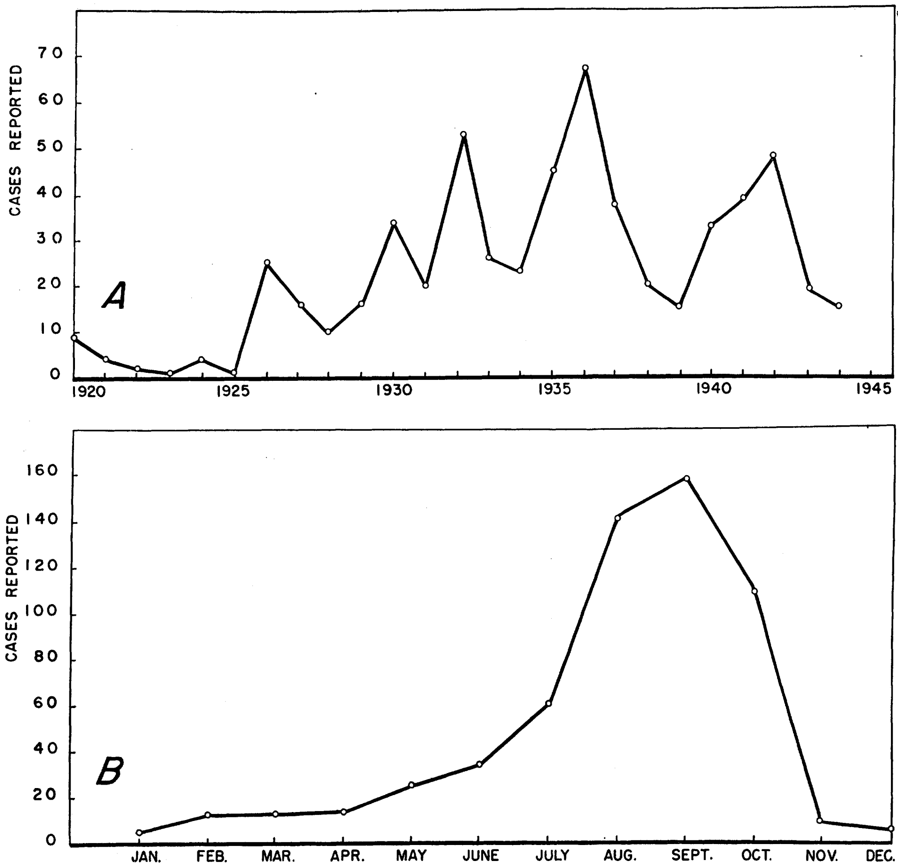


FIGURE 5.—Cases of malaria reported in Oregon, 1920–44: *A*, by years; *B*, by months. Total of 583 cases.

ENCEPHALITIDES

Encephalitis in man and equine encephalomyelitis, known collectively as encephalitides, are comparatively new recognizable diseases. Little was known of the causative agent, host range, and methods of spread until 1941, when Hammon and coworkers (*53*) published the results of their research in the Yakima Valley. They isolated the virus of St. Louis encephalitis and western equine encephalomyelitis, the principal types of encephalitis found in the Northwest, from *Culex tarsalis*. Never before had this virus been found in mosquitoes collected in an epidemic area. Several new viruses have been isolated from mosquitoes by various research workers, and it is suspected that they might produce clinical encephalitis in man.

The epidemiology of the encephalitides is the most complicated of any of the insect-borne diseases. However, it is known that *Culex*, *Aedes*, *Culiseta*, and *Mansonia* mosquitoes can serve as experimental vectors of western equine and St. Louis viruses (*49, 50, 51, 52, 55*), and species of the first three genera have been found naturally infected.

Culex tarsalis undoubtedly is the primary vector of western equine encephalomyelitis and St. Louis encephalitis in the Northwestern States. In one year Hammon and coworkers found 1 out of every 386 of these mosquitoes caught to be infected. This mosquito feeds on man, horses, mules, cattle, sheep, pigs, dogs, ducks, doves, pheasants, and chickens (*75*). It breeds in permanent ponds, barnyard puddles, irrigation seepage, and along the margins of streams. The problem is complicated also because birds serve as reservoirs of the virus (*55*). As many as 2400 cases of equine encephalomyelitis have been reported in 1 year in Idaho (1935), 726 in Washington (1940), and 525 in Oregon (1936). Figure 6 shows the numbers of cases reported in the Northwest from 1935 through 1951.

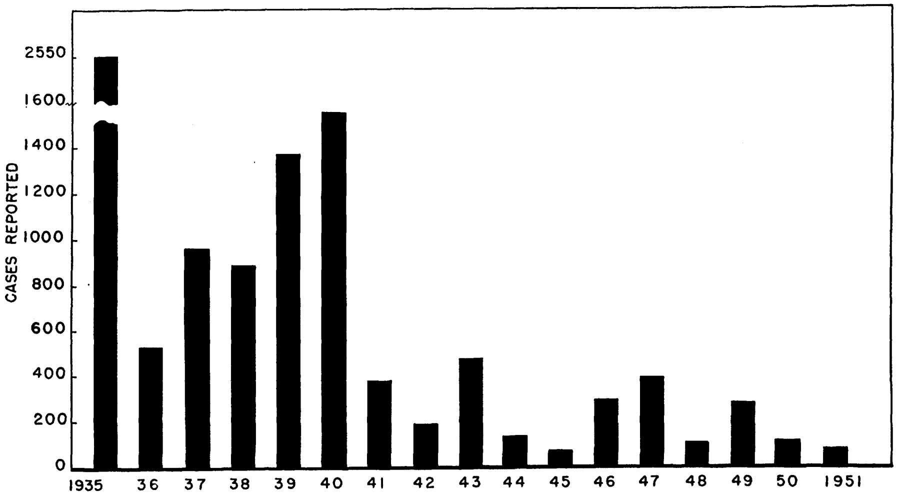


FIGURE 6.—Cases of infectious equine encephalomyelitis reported in Idaho, Washington, and Oregon, 1935–51. Total of 10,294 cases.

Until more is known as to the merits of mosquito control as a means of reducing the encephalitides, in known endemic areas with epidemic potentialities mosquito-abatement personnel must assume responsibility for making their control measures broad enough to include all mosquito species. The likelihood of reducing the incidence of encephalitis may be considered an added benefit in areas where mosquito control is justified on the basis of relief from irritating annoyance.

ASSOCIATIONS OF SPECIES IN THE NORTHWEST

The mosquitoes occurring in the Pacific Northwest may be grouped as follows according to their ecological habitat or association (*134*):

- Temporary bodies of water
  - One generation annually
    - Floodwater
    - Rain pools
    - Snow water
    - Tree holes
  - Several generations annually
    - Irrigation water
- Permanent bodies of water—several generations annually except *Mansonia*
    - Permanent ponds
    - Tidal water
    - Log ponds and water in artificial containers

Each association at different times and in different places may include species typical in other associations. The species in some of these associations cause more serious annoyance than do those in other associations. The fact that the species in the floodwater, rain pool, and snow-water associations have only one brood a year greatly simplifies control operations. Frequently, however, they may be complicated by the extent and inaccessibility of the areas requiring treatment (fig. 7).

FIGURE 7.—Floating debris makes it difficult to control floodwater mosquitoes.

The ecology of a few areas in the Northwest has been so altered by the construction of dikes, ditches, or dams in connection with irrigation projects that an entirely new association of mosquito species has resulted. For example, the Bonneville Dam has prevented the spring flooding of a large acreage overgrown to wil-

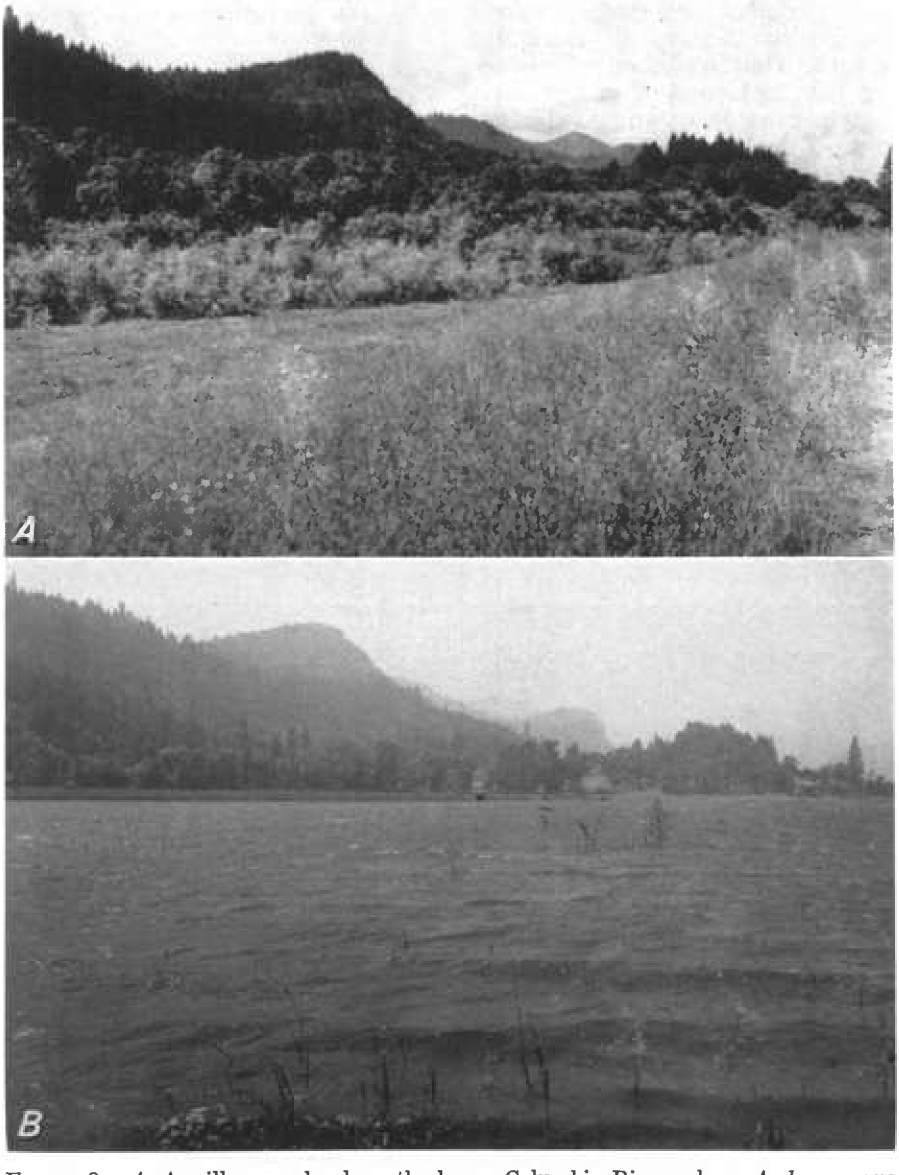


FIGURE 8.—*A*, A willow swale along the lower Columbia River where *Aedes vexans* and *sticticus* bred before it was permanently flooded by the Bonneville Dam. *B*, The same area after it was permanently flooded; *Anopheles* and *Culex* replaced *Aedes* mosquitoes.

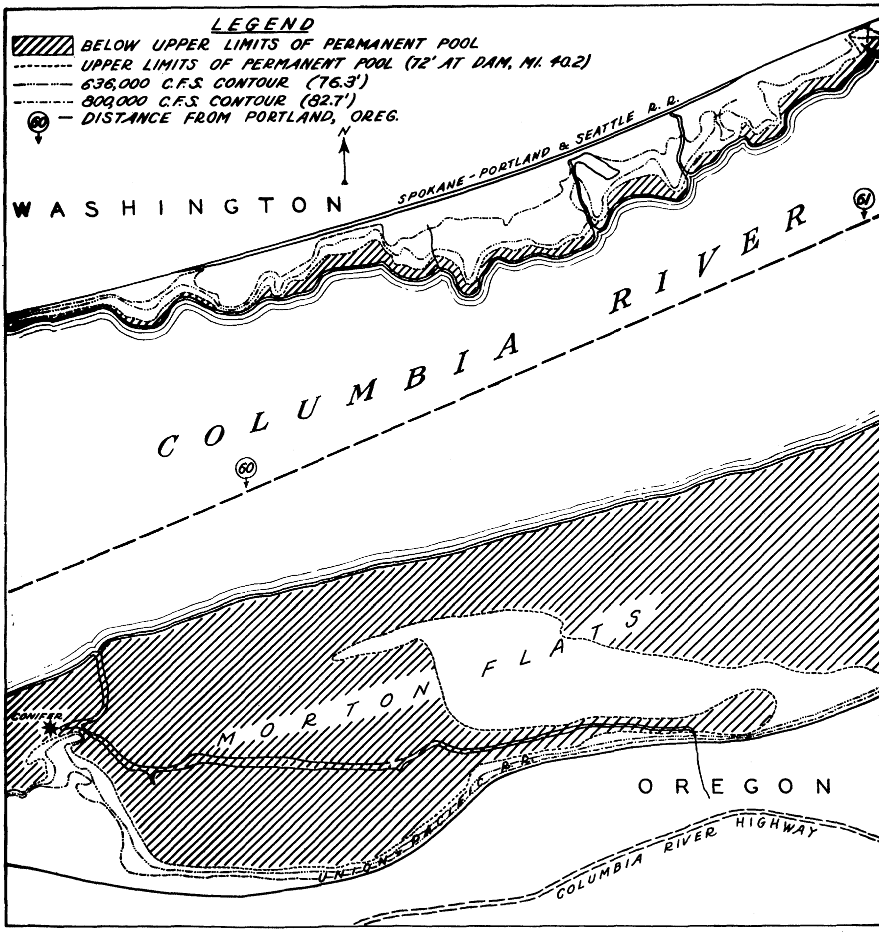


FIGURE 9.—Diagrammatic sketch of willow flat in figure 8, showing extent of mosquito breeding under natural and controlled water levels.

lows for 50 miles or more above the dam (*135*). These willow flats, (figs. 8 and 9), now permanently covered with water, no longer produce hordes of *Aedes vexans* and *sticticus* mosquitoes, but do provide marginal areas in some places suitable for the production of *Anopheles, Culex tarsalis,* and *Mansonia.* Grand Coulee Dam has afforded vast breeding grounds for *Aedes dorsalis, Anopheles,* and others that were not present before the area was irrigated.

An association of species may also change with the advancing season. In the irrigated sections of the Yakima Valley practically all of the first mosquitoes are *Aedes,* whereas after the irrigation water forms permanent ditches and ponds the next outbreak will contain numbers of *Culex tarsalis* and *Anopheles freeborni.*

FLOODWATER

AEDES VEXANS and *STICTICUS*

Along the banks of the Columbia River from the Cascade Mountains to the sea are many areas that overflow each year (fig. 10). The annual freshet usually occurs in May or June; the earliest date recorded for the flood crest is March 19 and the latest is July 4. These areas are heavily overgrown with willow brush and, at slightly higher elevations, with cottonwood, briars, and small shrubs; still higher are the conifers.

The normal mean level of the river is 7.1 feet. The flood crest is rarely so low as 10 or 12 feet. In most years it reaches at least 16 feet and one year in five it goes as high as 24 feet. Once in several decades it has reached disastrous heights—about 30 feet in 1894 and 1948.

During the annual spring freshet swarms of *vexans* and *sticticus* (*47*) hatch when stimulated by the floodwater. Three or 4 days after emerging from their aquatic life, the adult mosquitoes spread over the contiguous territory for several miles. They become extremely annoying in residential sections of Portland, Oreg., and Vancouver, Wash., over agricultural lands, especially dairy and small-fruit farms, and also in amusement parks and on golf courses.

The larval season usually begins in April, rarely late in March, and is over shortly after the flood crest is reached in May or June. At most it lasts 3 months. For the remainder of the year, these willow swales are comparatively dry. Oviposition begins within a week or two after emergence, and probably continues during July and August in willow flats adjacent to the receding river.

In some seasons there is a single gradual rise and fall of the river and, although breeding is heavy over the entire valley at the same time, with proper organization good control can be established. More often the river rises and falls from two to four times, and with each new crest new hatching takes place on ground that has previously been flooded (fig. 11).

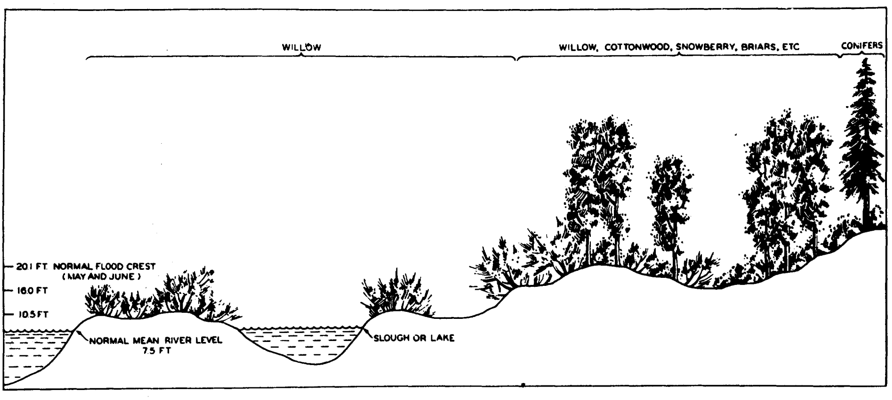


FIGURE 10.—Profile of Columbia River bank, showing breeding grounds of *Aedes* mosquitoes in willow brush and other vegetation.

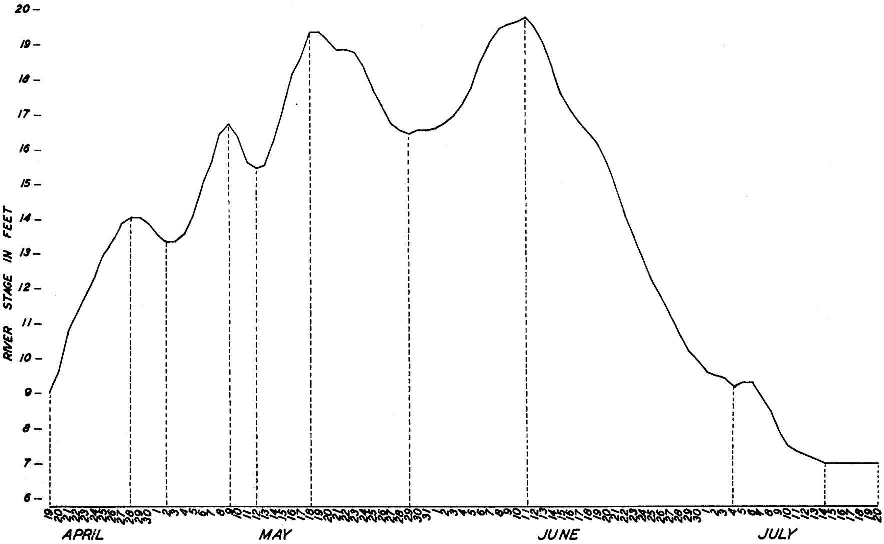


FIGURE 11.—Profile of Columbia River at Portland, Oreg., during flood of 1932. Each of the four flood crests shown produced *Aedes vexans* and *sticticus* mosquitoes.

Brush clearing has become an important control measure in a few restricted areas. Because of their greatly changed ecology, these areas become unsuitable for shelter and oviposition until heavily overgrown again.

Little ditching has been done in controlling mosquitoes of this association, because most of the breeding areas are flooded directly from the river, by water backing up into swales and sloughs or seeping through the sand into the swales. Where saucer-shaped swales can be emptied of water, ditches can be dug at the lower end, so that water will drain out of them quickly when the flood subsides. If the flood crest is a short one, these swales will dry before the larvae pupate, or the larvae will be carried into deep water, where they will be destroyed.

Much of the land bordering the Columbia River is now protected by dikes, and some of it has been filled above the normal flood crests. This kind of work is satisfactory and permanent, and greatly reduces the breeding of these mosquitoes.

A large mosquito-breeding area between The Dalles and Bonneville Dam has been permanently flooded. This flooding immediately reduced the breeding of *vexans* and *sticticus* and, as the ecology of the area became a permanent-pond type, new mosquitoes, such as *Culex tarsalis* and *Anopheles freeborni,* increased in numbers, although not seriously.

RAIN POOLS

AEDES ABORIGINIS, EXCRUCIANS, and *INCREPITUS,* and *CULISETA INCIDENS*

There are a great many temporary woodland pools of rain and seep water in the Coast Range of Oregon and Washington, where the rainfall is especially high early in the spring.

These pools, most of which are much less than an acre in size but occur for miles along the coast, are breeding places for vicious *aboriginis*, *excrucians*, and *increpitus*. These species may also be found in the snow-water association. Most parts of this rugged country are so thickly overgrown as to be nearly impenetrable (fig. 12). The ditching of the low spots reduces the mosquito population immediately, but ditching is expensive and considerable clearing is necessary to reach these breeding spots. Another kind of rain pool, undoubtedly containing some salt, occurs on the high rocks along the ocean. *Culiseta incidens* breeds in these pools.

SNOW WATER

AEDES COMMUNIS, HEXODONTUS, INCREPITUS, FITCHII, and *CINEREUS*

These *Aedes* species are found widely scattered along the backbone of the Cascade Range, in the mountains of eastern Oregon and Washington and in Idaho. The larvae appear in the innumerable pools and ponds formed by melting snow in April, May, or June. These mosquitoes breed also at the margins of lakes, the levels of which are raised by melting snow and lowered again when the excess water evaporates and seeps into the soil.

The mountainous areas of the Northwest are great recreational centers where visitors from every part of the United States camp, fish, hike, or pick blueberries from May through September. Visitors who have suffered from these mosquito hordes, which are vicious biters, will not remain long and probably will not return.

Perhaps in some places control by ditching or treatment from aircraft cannot be justified at present. However, until more economical means are found, some relief can be obtained locally by treating brush and other mosquito-sheltering vegetation around camp and resort sites with DDT sprays. Two of these treatments per season will greatly reduce annoyance by these species. At times of greatest mosquito activity, as at dusk, space sprays may be used.

Many of these areas are inaccessible until June because of heavy snow, and, if larvicide applications are contemplated, the materials and equipment must be taken into the area the preceding fall. After mid-June these mosquitoes are on the wing and are widely dispersed. These mosquito-breeding areas can also be treated when dry, late in the fall, with a residual spray or dust that will remain effective and kill the young larvae as they hatch from snow water the next spring. This method cannot be depended on for complete relief, however, because migrating mosquitoes may fly into the treated area.

Some semipermanent work has been done in this region by the Forest Service. Ditches have been dynamited in the heavy peat soil, not so much for draining pools of snow water as to maintain the levels of lakes whose upper margins otherwise produced larvae when temporarily flooded. The snow water and seep water then quickly drain into the lakes, the levels of which are fairly well maintained by dams at the outlets. This type of mosquito-control work is distinctly advantageous to wildlife. It creates additional marginal areas dry enough for upland birds early in spring, and at the same time increases and maintains the extent of lakes suitable for fish and waterfowl.

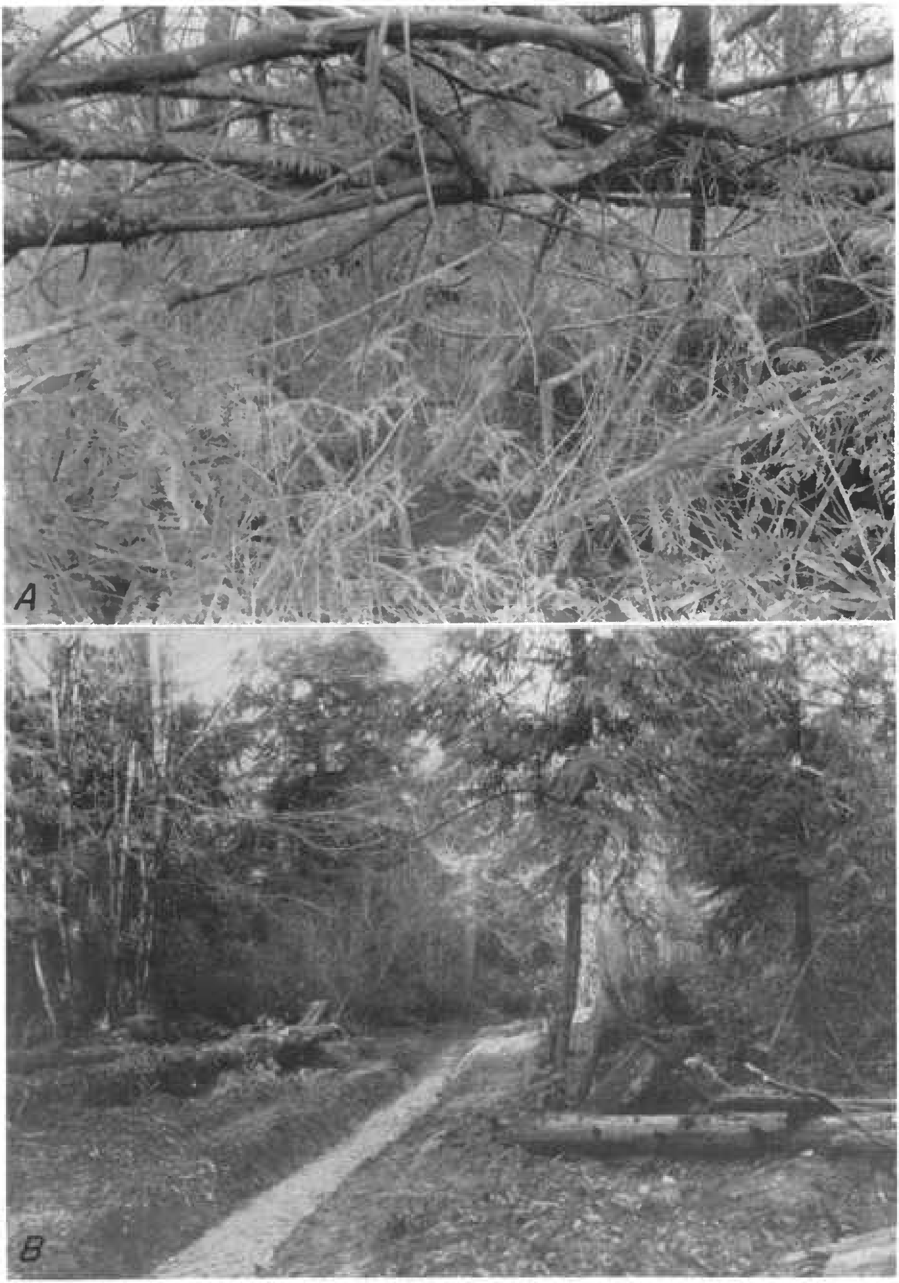


FIGURE 12.—*A*, Temporary rain pool in the Coastal Range. *B*, The same area after it had been cleared and ditched.

TREE HOLES

AEDES VARIPALPUS

Here and there along streets, in parks, or in the deep forest are tree holes that contain water for long or short periods (fig. 13). In these holes one can nearly always find *varipalpus* larvae (*114*), and west of the Cascade Range they can be found at almost any time of year. These mosquitoes overwinter as eggs and as larvae. They are severe biters close to their breeding place, but frequently the tree holes are difficult to discover. When found they can be treated with DDT or filled with sand.

IRRIGATION WATER

AEDES DORSALIS, VEXANS, and *NIGROMACULIS, ANOPHELES FREEBORNI* and *PUNCTIPENNIS,* and *CULEX TARSALIS*

In large areas in eastern Idaho, Oregon, and Washington irrigation is practiced. Some of these areas are flooded with a thin sheet of water from the surrounding mountains. They are generally used as hayfields, which either go dry naturally or are made to go dry by diverting the water before haying time. *Aedes dorsalis* or *vexans* mosquitoes appear in May and June and are exceedingly abundant in these so-called marshes of 10,000 to 60,000 acres but the anophelines and culicines have scarcely time to propagate except where the water is turned into border ditches. At haying time it is difficult to hold labor because of the mosquitoes. Men wear head nets and heavy clothing for protection. Horses have been known to lie down while harnessed to mowing machines, in their frantic efforts to rid themselves of these tormentors. The pests cause beef cattle on summer pasture to lose weight and reduce the milk flow in dairy herds. They also prevent the development of otherwise desirable real property and hinder all kinds of recreational activities.

FIGURE 13.—Tree hole where *Aedes varipalpus* larvae are found.

The only means of control would be to treat large areas from aircraft, but this measure is seldom economical because of the great size of the infested areas and the sparse human population. The problem is how to furnish an adequate supply of water to the fields and then dry them up within a week. The border method of irrigation partially meets this problem where it can be employed, but there is seldom an adequate supply of water that can be held for later release.

PERMANENT PONDS

ANOPHELES FREEBORNI* and *PUNCTIPENNIS, CULEX TARSALIS, CULISETA INCIDENS* and *INORNATA*, and in some areas *MANSONIA PERTURBANS

Contrary to common belief, ponds of permanent water present the least mosquito nuisance in the Northwest. The anophelines and *Culex tarsalis* that breed there do not become numerous until late in the season and are seldom very annoying. However, *freeborni* is a potential carrier of malaria and *tarsalis* of encephalomyelitis and encephalitis. Mosquitoes that transmit the last two diseases should be controlled whenever practicable. The anophelines are widespread throughout the Northwest late in the summer, but malaria has been endemic only in the upper Willamette Valley of Oregon. Oxbow ponds (fig. 14) are numerous for 30 miles along the Willamette River and in some places occur in an area 5 miles wide.

TIDAL WATER

AEDES DORSALIS

Only one mosquito species breeds in salt marshes along the coast of Oregon and Washington. Except for certain tidal flats adjacent to Puget Sound, the coastal breeding areas are small and more or less isolated. *Aedes dorsalis* breeds abundantly in these salt-marsh areas, as well as in the alkaline irrigation water to the eastward. These mosquitoes probably fly but short distances, but can be a severe annoyance to man. They are vicious biters by day and have caused a decrease in the milk production of dairy cattle pastured on the marshes.

FIGURE 14.—A typical oxbow pond along the Willamette River from which large numbers of *Anopheles freeborni* and *punctipennis* have been taken.

LOG PONDS AND WATER IN ARTIFICIAL CONTAINERS

CULEX PIPIENS and *TARSALIS, CULISETA INCIDENS,* and *ANOPHELES PUNCTIPENNIS*

Large numbers of these mosquitos breed in log ponds, and in many towns in western Oregon and Washington they are the only source of mosquito annoyance. *Culex pipiens* is occasionally a serious pest near heavily polluted ground pools, and in drains of septic tanks, offal disposals, and other sewage-polluted water. Wooden, tin, and rubber receptacles also harbor this species as well as *Culiseta incidens,* sometimes in numbers sufficient to annoy the occupants of several homes. *Anopheles punctipennis* larvae are sometimes found in rain or water barrels in this region, if the water is fairly clean.

MOSQUITO CONTROL

Mosquito control has become increasingly important during the last few years. In many parts of the country it has become an essential part of good living. The recent incrimination of *Culex tarsalis* as a vector of equine encephalomyelitis and its relation to sleeping sickness in humans has stimulated interest in mosquito control to reduce the incidence of this disease. Although malaria is of little importance in the Northwest, it has been endemic in the upper Willamette Valley in Oregon for over 100 years (*146*).

The mosquito problem of the Pacific Northwest is largely agricultural and recreational in character (*174*). Mosquitoes affect the farmer, his family, his employees, and his livestock. They cause financial losses to stockmen, dairymen, and general farmers.

Mosquitoes, by constant annoyance, cause livestock to lose weight and reduce milk flow. They often drive livestock from lush pastures to barren hillsides and thus further reduce flesh gains. Annoyance from mosquitoes is a severe trial to fruit pickers, and may cause them to refuse to work in the fields.

The use of recreational areas at some beach and mountain resorts is greatly restricted by mosquito annoyance at the very time of year when the most people are on vacation. The losses from reduction of property values and attendance at amusement parks, and from injury to livestock are frequently much greater than the cost of mosquito control.

Mosquito control is a specialized subject and one that requires sound judgment, a background of entomology, some training in engineering and, because of the innumerable personal contacts, an understanding of human psychology. Above all one must know the different species. their life histories, and habits, in order to apply practical measures against them. In mosquito control one can do the right thing, but do it at the wrong time, and so meet with failure.

SURVEYS

Before an effective mosquito-control program can be undertaken, a survey must be made of the area. Such a survey must be made by an entomologist or a specialist having knowledge of the biology and habits of mosquitoes, and of the diseases they carry. In addition to finding out where the mosquitoes are and what species are present, information must be obtained on their breeding places, and such other data that entomologists, sanitary engineers, and mosquito-abatement engineers will need in planning a control program.

If the mosquito-control project is aimed at the reduction of malaria or equine encephalomyelitis, the presence of the disease itself indicates in some measure the species involved. A study of the distribution of the disease serves to point up the problem, and a survey of mosquito species aids in developing the plan of procedure and estimating costs. When relief from mosquito annoyance is the main consideration, a survey is necessary to determine the limits of the infestation and the relative importance of each species, since more than one kind is usually present. Even in one county of the lower Columbia River Valley the problem is complicated by mosquitoes that breed in snow-water, floodwater, artificial containers, and permanent ponds.

A mosquito survey is begun by collecting and identifying both larvae and adults during a mosquito outbreak. Because the flight range may be unknown, this collection should extend for some distance beyond the limits of mosquito annoyance. Since mosquitoes have no regard for municipal, county, or State boundaries, it is sometimes necessary to control them in one State or county to protect the citizens of another.

Some mosquito-abatement districts maintain collections of identified species of mosquitoes found locally. These collections are of use in quickly identifying species brought in for determination and for educational purposes.

A survey of the breeding places should determine their extent and nature, whether permanent or temporary, as well as the topography and natural drainage of the area. At least one entire mosquito breeding season is necessary for such studies. Two or three seasons is even better. In the Payette Valley of Idaho *dorsalis* predominates in May and *nigromaculis* in July and August. Along the Columbia River flood crests vary greatly from year to year, or they may occur two or three times during one season. Each flood stage produces its brood of mosquitoes and, because of their habit, the relative abundance of the species may vary with the height of the flood. Several years of study are required, therefore, before reliable averages can be determined. Fairly effective control operations can be started before such an extensive survey is completed, but without adequate information control may be highly wasteful and may result in loss of public confidence.

HAND COLLECTIONS

Collecting mosquitoes while they are biting is the simplest and most direct method of determining the proportions of the different species. Such collections are usually made with a chloroform tube or other type of killing bottle. One procedure is to stand or sit at the selected place and, after allowing a minute or two for the mosquitoes to accumulate, to collect them as they alight over a 10-minute period. Three 10-minute periods may be totaled and multiplied by 2 for the hourly rate. One person working alone can collect the mosquitoes landing on the front of his trousers. If two are working together, one can collect those alighting either on the shirt or bare back of his companion.

When mosquitoes are abundant, the numbers caught can be increased by placing a short paper funnel, or guard, in the mouth of the collecting tube. The collector can then catch the next specimen without waiting for the first one to succumb to the chloroform fumes. The guard also conserves the strength of the chloroform and prevents the loss of specimens when the mouth of the tube is turned downward. In heavily infested areas 100 or more mosquitos have been taken in 10 minutes with a tube of this sort.

When two or more persons are to make collections at different places, they should make a preliminary collection at one place to determine the relative attractiveness and dexterity of the different collectors, since much variation has been found in these respects.

Certain species, such as those of *Anopheles* and *Culex*, can be obtained by daytime collecting in dark corners and underneath buildings, where they spend the daylight hours. However, *Aedes* species in the Northwest may be taken best at dawn or dusk and on cloudy days, when the humidity is high, by going to their breeding areas or places where they are reported to be annoying.

For making the collections a series of stations well distributed over the area under observation are selected. At each location the most favorable place should be selected after an examination of the entire area. Collections are made daily, weekly, or biweekly. For data on comparative abundance in different parts of the area, or at different times of the year, collections should be made under conditions as nearly uniform as possible.

Collections made during the first flight period (just at dusk) may average much higher than daylight collections. The numbers will vary with climatic conditions.

We have compared hand collections with those made with a New Jersey light trap in a total of 10 hours of hand collecting for 10 minutes at hourly intervals (*133*). Approximately three-fourths as many female mosquitoes have been taken as with the light trap in 60 hours. In hand collecting, however, one seldom obtains the rare species, and practically no males, as are taken with the light traps.

TRAP COLLECTIONS

For most species the New Jersey light trap (*104*) (fig. 15) is

FIGURE 15.—A New Jersey light trap in operation.

very useful for obtaining samples of mosquito populations. The traps are placed at strategic places throughout the area and are usually operated on one or more nights each week. They should be hung in an open space, with the light itself 5 or 6 feet from the ground, and they should not be placed near a street or other competing light. These traps are of no value in controlling mosquitoes in an area; they serve only as a sampling device as an aid in determining the effectiveness of a control program.

The number of mosquitoes caught per night in a trap frequently runs into the hundreds and, since many other kinds of insects are also found in the killing bottles, the task of separating and identifying the material is often difficult. Rare species and males not taken while biting appear in the light-trap collections.

The different species are not equally attracted to the lights. They are comparatively ineffective in trapping *Aedes* in the Northwest. Our highest record for *vexans* and *sticticus* was 444 individuals in one night, even though they were very abundant in the area. In southeastern Oregon as many as 1,700 mosquitoes were taken in a trap in one night. Of these, 945 were *Aedes dorsalis* and the rest *Anopheles freeborni, Culex tarsalis,* and *Culiseta inornata.* We have taken more than 1,200 mosquitoes, mostly *tarsalis* from one trap in the Yakima Valley.

Reeves and Hammon (*117*) have designed a large box trap, mounted on a two-wheel automobile trailer, for collecting live mosquitoes. This is a modification of the New Jersey light trap in that the insects do not have to pass between the blades of a fan and are kept alive instead of being killed in a cyanide jar. As many as 1,055 mosquitoes have been collected in one of these traps in a single night.

Animal-baited traps have been used in the Tropics (95), but so far as we know they have not been used in the Northwest.

A mechanical trap (fig. 16) has been used in the Arctics (*145*)

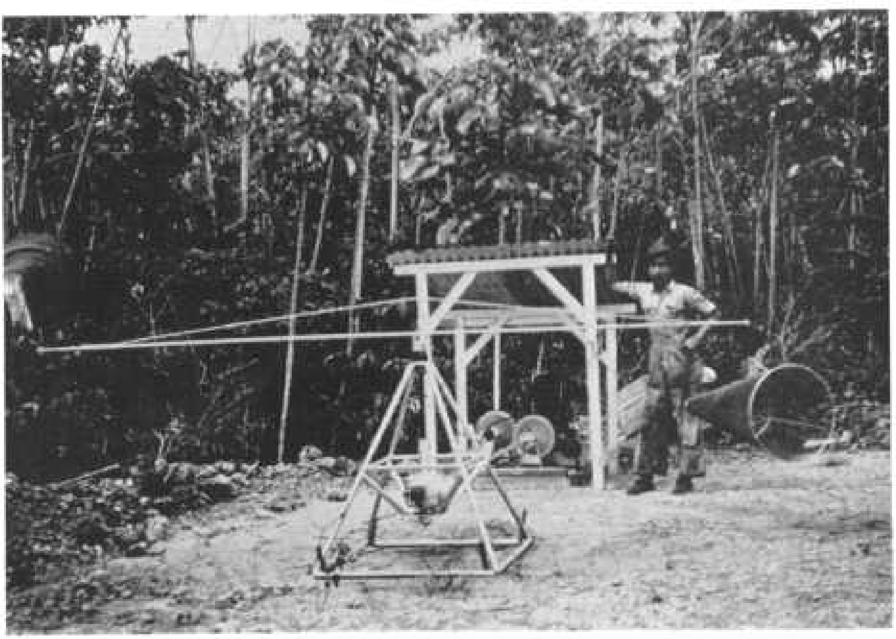


FIGURE 16.—A mosquito-collecting device operated by a gasoline motor.

with fair success and has some advantages over the New Jersey light trap. The trap is operated by a gasoline motor and does not depend on electricity or darkness for effectiveness. This rotary trap catches all flying mosquitos that happen within its collecting range, and by this means an exact number of cubic feet of atmosphere per time unit can be sampled. A trap equipped with two nets and operated at 55 r.p.m. removes the insects from approximately 500,000 cubic feet of air per hour. By mounting a cone of this trap on the fender of an automobile (fig. 17) (126), one can take continuous samples of mosquito populations while traveling at dusk. A serious disadvantage of this type of trap is that it may injure the specimens when they are unattended for long periods.

COLLECTIONS OF LARVAE

The collecting of larvae in mosquito surveys is done mainly to locate breeding places and determine their importance. Such collections also show the comparative abundance of the different species. The presence or absence of larvae determines whether an area should be treated with a larvicide. If larvae cannot be found, we recommend against treating a "likely looking" area. Sometimes the productivity of a breeding area can be measured by placing cloth nets or screen cages over the water.

Breeding places are of two general classes, permanent and temporary, but the status of a given area may change over a period of time. *Anopheles*, *Culex*, *Culiseta*, and *Mansonia* occur typically in permanent breeding places,

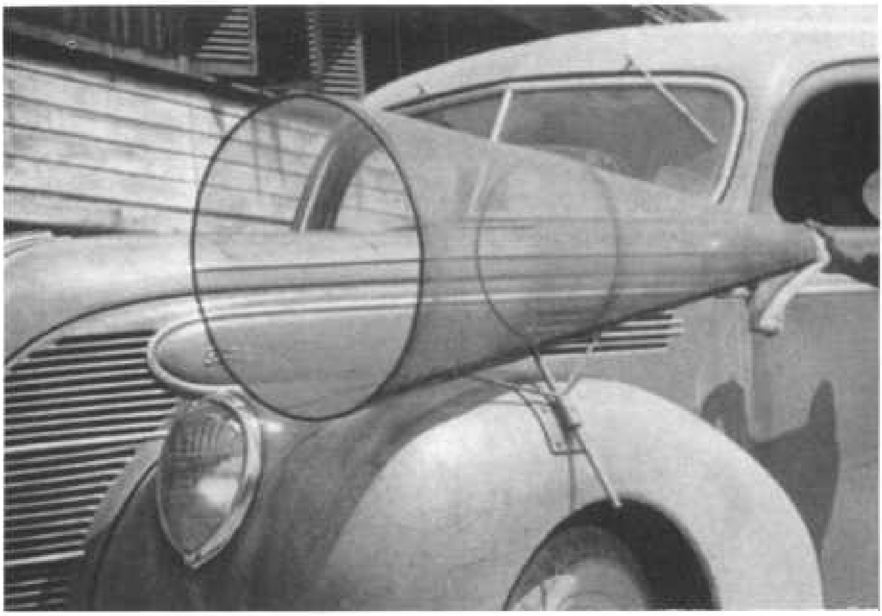


FIGURE 17.—A cone screen mounted on the fender of an automobile for sampling mosquito populations.

whereas the *Aedes* mosquitoes of the Northwest breed in areas that are flooded only a few weeks in the year. Because most of these floods occur but once a year, *Aedes* has only one brood a year, but where floods are more frequent a brood follows each flooding.

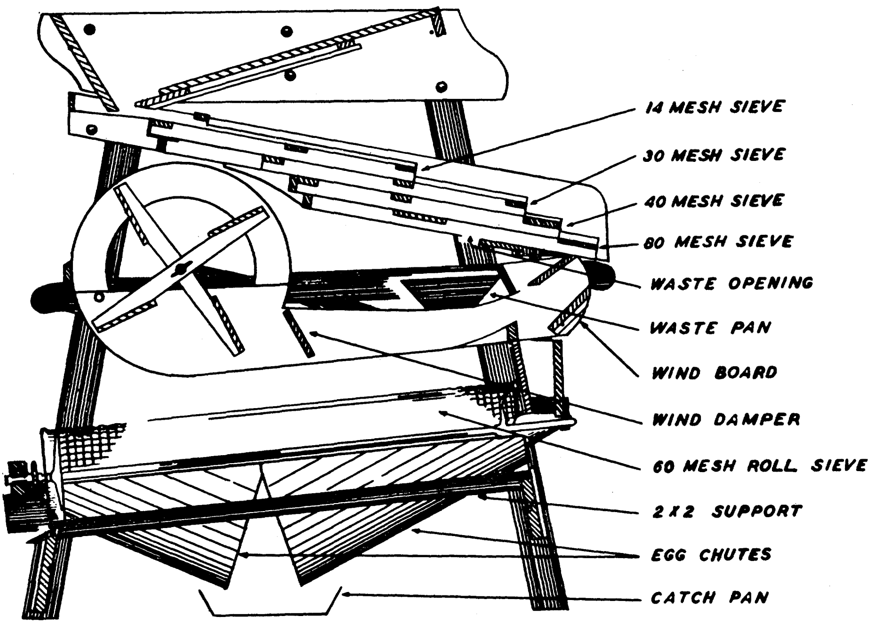


FIGURE 18.—Diagram of a grain cleaner modified for separating mosquito eggs from soil.

Because of deep snow in the high mountains, it is often impossible to get to those breeding areas in June before the mosquitoes have emerged from the snow water. It is sometimes possible to obtain data from these areas by taking samples of soil from dry depressions late in the summer and flooding them with water in the laboratory. Some experience is required, however, before one can become adept in choosing just the right sample for flooding. If eggs are present, and if they have been laid several weeks before the sample is taken, they will hatch within a few minutes, and after several hours the small larvae can be seen readily in strong light. Several factors little understood complicate this technique. Apparently the elements of time, dryness of soil (*166*), species of mosquito, and temperature all influence the hatching of these *Aedes* mosquitoes.

COLLECTIONS OF EGGS

In areas where mosquitoes lay their eggs on the ground, the extent of the breeding areas can be determined by sampling the top layers of soil and debris (*27*). It is impossible to recover many eggs without examining and separating a large volume of soil.

The samples of soil and debris are dried until almost dusty, passed through a mesh sieve, and then through a modified grain cleaner (fig. 18) (*36*) to concentrate the eggs in a very small quantity of soil. The eggs can be picked out of the infested soil under a microscope, with a moistened camel's-hair brush. This is best done by spreading the soil over a white background.

A grain cleaner 24 inches wide is used as a basis for the separator. It consists of four shaker sieves, a roll screen, and an air blast. The sifted soil is placed in the hopper and, as it feeds down over the shaker sieves, the coarse material is removed by 14-, 30-, and 40-mesh sieves. The eggs and the soil particles of the same size pass through these sieves, but the 80-mesh sieve below separates the particles of material that are smaller than the eggs, which drop down the opening into the roll screen. On the way down some of the light particles the same size as the eggs are blown out by a breeze from the fan. The turning motion of the roll sieve causes the eggs to pass endwise through the 60-mesh roll screen. As they slide down the chute to the catch pan, waste material passes out of the lower end of the roll.

The meshes used are suitable for concentrating eggs of *sticticus* and *vexans*. It has also been used for obtaining eggs of *dorsalis*, although the mesh of the selecting sieve is slightly large for them. To sieve out the eggs of other species sieves of larger or smaller mesh can be used. The separator can be equipped with a ¼-horsepower electric motor, or can be operated by hand with a crank.

The separator recovers about 90 percent of the eggs from the soil, and the final product may contain from 10 to 200 eggs per cubic centimeter of soil. In the lower Columbia River Valley the average number of *vexans* and *sticticus* eggs is about 85 per cubic centimeter.

To prevent the eggs from drying out, each 100 cubic centimeters of soil containing eggs should be moistened with 8 to 15 cubic centimeters of water, depending on the type of soil.

Husbands (*7*) has used a vacuum-cleaner suction device for picking up eggs in pasture areas and has developed technique for separating them from the gathered soil and debris.

ENGINEERING SURVEYS

Surveys in connection with mosquito-control projects should include an engineering survey to determine the possibility of eliminating the breeding places. Reclamation of land, diking against floods, and maintaining water levels are permanent solutions to the problem. Such a survey will determine whether such methods are feasible and the approximate cost. Will the local budget justify drainage or other construction, or is the use of insecticides the only practicable measure? Will increased land values and recreational advantages offset the cost of mosquito control? The legality of the proposed work and the need for obtaining easements on private property must also be considered. An engineering survey to answer such questions will provide a background upon which to base an effective control program.

CONTROL OF LARVAE

ELIMINATION OF BREEDING PLACES

Wherever possible and practicable we recommend the control of larvae by eliminating the breeding places by draining, diking, and sanitation, or by maintaining permanent water levels. In some places brush clearing is

FIGURE 19.—*A*, A tidal marsh at high tide; flooded pothole in center breeds *Aedes dorsalis*. *B*, Pot holes shown in *A* after being connected with the drainage channel by ditches.

effective. Where water levels are maintained, control workers must be on the lookout for *Anopheles*, *Culex tarsalis*, and *Mansonia*, which breed in permanent ponds.

Drainage undoubtedly is one of the quickest and best methods of controlling mosquito species in the Northwest, but construction and labor costs are usually prohibitive. It is highly advantageous in several locations in the Pacific Northwest. Many of the tidal-marsh breeding areas along the seacoast can be freed of *Aedes dorsalis* mosquitoes by digging ditches to connect the numerous pot holes in the marshes with the main channels of streams (fig. 19). The pot holes are drained of water as the tide flows out, and the mosquito larvae are carried along to deeper water, where they perish before becoming pupae or adults. Such ditches need cleaning every year.

Ditches have been highly effective also in the Coast Range of Oregon and Washington (*131*), where the rainfall is abundant at all seasons. Early in the spring innumerable temporary woodland pools of rain and seep water are heavily infested with *Aedes aboriginis* and *fitchii*. Most of this country is rugged and so thickly overgrown as to be nearly impenetrable. If these areas can be opened up with hand labor and connected by ditches to some stream or other drainage, the mosquito pest can be greatly reduced. This type of work is semipermanent and requires a certain amount of annual maintenance.

Very little ditching has been done along the Columbia River bottomlands, because most of the breeding areas are flooded directly from the river or by water backing up into swales and sloughs. However, a few isolated saucer-shaped swales have been ditched at the lower end so that the water quickly drains out of them as soon as the flood subsides. If the flood is of short duration, the mosquito larvae are carried out of the swale into deeper water, where they are destroyed. These ditches also allow fish to enter the infested swale and devour the larvae.

Many acres of bottom lands along the lower Columbia River have been diked against the annual floods of the river. The financial justification of such work lies in the increased value of the land for agricultural purposes; nevertheless, diking of this acreage has reduced mosquito breeding to a minimum.

Sanitation as a mosquito-control measure includes the destruction of tin cans and other artificial containers in which *Culex pipiens* and *Culiseta* breed. It also includes the treatment of fire barrels and log ponds (fig. 20) with

FIGURE 20.—Treating a log pond with a mosquito larvicide.

insecticides, and, in permanent ponds, the removal of aquatic vegetation and other shelter for the larvae. Septic tanks must be inspected for leaks and unused wells and cisterns for the pres-

FIGURE 21.—*A*, Depression in a mountainous area where mosquitoes breed in melting snow water. *B*, Same area in July. When area is completely dry mosquitoes lay their eggs on the ground.

ence of larvae. *Culex tarsalis, stigmatosoma, and pipiens* and *Culiseta incidens* are usually abundant in log ponds late in the summer.

Thousands of acres of land in the Northwest which have become valuable through irrigation are now producing mosquitoes so abundantly as to present a serious menace to man and beast. In these areas wise use of water and an effective device for manipulating water levels are imperative.

Most of the irrigated hayfields in the valleys of eastern Washington, Oregon, and Idaho, which produce myriads of mosquitoes, have an unlimited water supply early in the spring. When water is applied in excessive amounts without provision for adequate drainage, optimum breeding conditions exist for several species of *Aedes* and *Anopheles*, and for *Culex tarsalis*.

The problem is to furnish an adequate supply of water to the fields and dry them up within a week's time to reduce the mosquito nuisance. The border method of irrigation (28) not only meets this problem but is also economical in water consumption. In this method the fields are divided into a series of strips by low levees, or dikes, running parallel to the general slope of the land. Water is turned into the upper end of each strip from a larger border ditch and flows across the strip in a thin sheet. When the strips have been flooded for a few days, the flow of water is checked. The mosquito larvae either die on the dry surface or are carried into drainage ditches, which may be stocked with mosquito-killing fishes or treated with a larvicide.

The border method of irrigation, which makes short-period flooding possible, is a better farming practice than any other irrigation method, because it provides an efficient and comparatively cheap means of controlling mosquitoes. It also prevents the growth of such weeds as foxtail barley and marsh grass, commonly found growing where irrigation has been excessive.

In mountainous areas there are many small depressions that have no natural drainage. Early in the spring they are flooded to a depth of several inches with icy water, which drains from the surrounding banks of snow. This water is frequently teeming with mosquito larvae, and in many inaccessible areas adults may emerge even before roads and trails have been cleared of snow (fig. 21). Treatment of these depressions with a larvicide, such as DDT wettable powder, in September and October will control these larvae.

The manipulation of water levels to reduce mosquito abundance can be done in two ways. Small dams can be constructed across the outlets of the lakes and ponds to hold the water level constantly high and thereby prevent the deposition of eggs along the upper margins (fig. 22). Satisfactory control can also be effected on the upper margins by digging ditches parallel to the contours to collect the seepage, and secondary ditches may be dug to transport the seepage to the main channels of streams, or to ponds. Mosquitoes may later oviposit at the upper margins, but the eggs cannot hatch, since all free water quickly flows off. This method of control, however, is limited to very special situations.

In some isolated areas where thickly matted jungles of willow brush furnish maximum protection for egg laying, *vexans* and *sticticus* have been controlled for a few years by clearing the areas

FIGURE 22.—*A*, Permanent pond surrounded by mountain meadows, which are covered with temporary water early in the spring. *B*, Same meadows, drained of surplus melting snow and seepage into large ponds and held by dams.

of all herbaceous growth (fig. 23). Although the effectiveness of this procedure has been questioned, we found it practical for short periods. We believe temporary control was established by a radical change of the microclimate of the breeding site, since shade, humidity, and freedom from strong winds are essential for maximum mosquito development. This type of control can be considered no more than temporary, however, because brush,

FIGURE 23.—*A*, Willow flat along the lower Columbia River offers shelter and breeding places for floodwater mosquitoes. *B*, Same willow flat cleared of shade and other protection and thus freed of mosquitoes. Regular maintenance is necessary to prevent their return.

grass, and herbaceous perennials soon return. However, pasturing stock and some annual clearing in these areas will reduce their capacity for producing mosquitoes.

USE OF LARVICIDES

Where it is not feasible to eliminate mosquito-breeding places, control may be accomplished by treating them with a larvicide. Before DDT and other recently developed insecticides were available, petroleum oil was used against all species and paris green against *Anopheles*. A light distilled fuel oil (No. 2) was widely used, but it was not consistent in its effectiveness because it was made from different types of crude petroleum.

Recently three spreading agents have been found particularly effective when added to No. 2 fuel oil (Knipling, Gjullin, and Yates *87*). They are sulfonated sperm oil (Nopco 1216), a phthalic glyceryl alkyd resin (Triton B-1956), and an 18-carbon-chain complex amine (Amine 230X). When 3 to 5 percent of one of these spreaders was added to this oil, adequate coverage and satisfactory control were obtained with about 6 gallons, instead of the usual 20 to 50 gallons, of oil per acre on fresh water.

Pyrethrum larvicides, as developed by workers in New Jersey (Ginsburg *33*), are very beneficial under certain conditions. They are soap emulsions of pyrethrum extract in kerosene, and are particularly adapted for use in garden pools containing valuable aquatic plants and fish, where other mosquito larvicides might be harmful. They are sprayed over the surface of pools at the rate of about 50 gallons per acre or 1 quart to 200 square feet of surface. A concentrate containing 66 percent of kerosene, 0.07 percent of pyrethrins, 0.5 percent of an emulsifier, and 33.5 percent of water can be purchased, and diluted with 9 parts of water. This larvicide is not recommended for use in the extensive willow flats along the Columbia River.

With the advent of DDT in 1942-43, the scope of chemical control of mosquito larvae was greatly enlarged. Other materials, such as TDE, BHC, lindane, toxaphene, aldrin, and dieldrin, developed since that time have also been tested.

DDT in oil solution has been widely employed as a mosquito larvicide (fig. 24). Concentrations of 1 to 5 percent in fuel oil No. 2, Diesel oil, or kerosene, with or without auxiliary solvents and spreaders, will control mosquito larvae. Except where resistance has been developed, (*18, 41, 88, 148, 169*), they are effective when applied at the rate of 0.05 to 0.4 pound of DDT per acre, depending on the species, the type of water, the amount of vegetation, and other factors. Emulsifiable concentrates are also satisfactory when diluted with water to give the required dosage, although they are not recommended where fish and wildlife are involved. A concentrate containing 25 percent of DDT, 65 percent of xylene or other solvent, and 10 percent of Triton X-100 or other emulsifier is satisfactory. The effectiveness of DDT-oil solutions has been increased by the addition of 0.25 to 0.5 percent of Triton B-1956. Long-lasting larvicidal action can be obtained, especially in local and restricted areas where applications of 1 to 2 pounds of DDT per acre does not present hazard to wildlife.

TDE, also called DDD, is particularly useful where fish are

FIGURE 24.—Applying a mosquito larvicide with a compressed-air sprayer.

present (*157*). Solutions and emulsifiable concentrates may be formulated the same way as those containing DDT, and can be applied at the same dosages.

BHC and lindane compare favorably with DDT and are superior where mosquitoes have become resistant to DDT. Dosages of 0.05 to 0.1 pound of the gamma isomer per acre are recommended.

Toxaphene has been found an effective substitute for control of DDT-resistant mosquito larvae in California and Florida. It is more toxic to fish than is DDT. and a dosage of 0.2 to 0.4 pound per acre is necessary for control.

Investigations with chlordane in the Northwest are incomplete, but preliminary data indicate that 0.2 to 0.4 pound per acre will provide satisfactory control.

Dieldrin is one of the most effective mosquito larvicides. A dosage of 0.1 pound per acre is satisfactory. It is recommended for use by experienced operators, but not by the general public because of its high toxicity to man, animals, and wildlife.

All these larvicides are effective, economical, and safe for use over large areas when applied by aircraft if the operation is closely supervised by specialists and trained pilots. DDT is usually applied at the rate of 0.1 to 0.2 pound per acre. A good solvent and carrying agent for 20 percent of DDT is a methylated naphthalene such as Velsicol NR70, Solvesso No. 3, or Shell 42 (*161*). Lindane is used at the rate of 0.05 to 0.2 pound per acre, technical BHC at the same rate of gamma isomer.

EPN has recently given excellent control of larvae in California, when applied as an emulsion or wettable powder spray at the rate of 0.075 pound of EPN per acre (Gjullin *40a*). Mosquito Abatement Districts in California used EPN successfuly during the 1952 mosquito season.

At the present time we have had very little experience with allethrin, the new synthetic compound chemically related to the pyrethrins (Gjullin *40a*), the active constituent in pyrethrum. It appears to be almost as effective as pyrethrins.

MATERIALS FOR CONTROLLING MOSQUITO LARVAE

Floodwater, irrigation water, tidal water, rain pools, and permanent ponds.—

No. 2 fuel oil, 25 to 50 gallons per acre.

No. 2 fuel oil with 3 to 5 percent of an emulsifier, 3 to 6 gallons per acre.

5-percent DDT-oil solution. For use in aircraft, 1 to 3 quarts per acre; for ground equipment dilute to 1 to 2 percent of DDT and apply 1 to 2 gallons per acre.

25-percent DDT emulsifiable concentrate. For application by airplane, dilute with 4 parts of water and use 1 to 3 quarts per acre; for ground application dilute to strength recommended for the oil solution.

Snow water.—Any of the treatments described above or a DDT solution, emulsifiable concentrate, or wettable powder applied to the breeding areas late in the fall before the ground is covered with snow. Apply 0.5 to 1 pound of DDT per acre.

Log ponds.—DDT emulsion prepared as described above, but applied about once a month as needed. A dosage of 3 quarts per acre or about 0.2 part of DDT to 1 million parts of water in the pond.

Fire barrels.—25-percent DDT emulsifiable concentrate, 1 cup to each barrel two or three times a year.

Tree holes.—50-percent DDT wettable powder, 1 or 2 tablespoonsful to each cavity once or twice a year. Such cavities can also be filled with sand, or a hole can be bored at the bottom to allow drainage.

Ornamental pools and rain barrels.—1-percent pyrethrum emulsifiable concentrate, 1 tablespoonful to 50 gallons of water as needed.

We have observed several ground-inhabiting beetles that are predaceous on *Aedes* eggs (*150*). The carabids *Trechus chalybaeus* Dej., *Agonum pusillum* (Lec.), *Pterostichus algidus* Lec., and *Bembidion* sp. destroyed the greatest number, 8 to 15 eggs per individual per week.

CONTROL OF ADULTS

Before DDT and other new insecticides became available, mosquito-control measures were usually directed against the larvae, because the insects were most vulnerable in that stage. These new materials, however, are equally effective against the adults.

Screens (16-mesh), head nets, repellents, aerosols, and space and residual sprays are all used for protection against mosquito annoyance.

REPELLENTS

During World War II several new mosquito repellents were developed (*128*, *158*, *160*). When properly applied to exposed skin, about 12 drops for the neck, face, and both hands, they will prevent mosquito bites for 2 hours to half a day, depending on the person, the species of mosquito present, and mosquito abundance. The best known of these repellents are dimethyl phthalate, Rutgers 6-12, and Indalone, and mixtures of them, usually 6 parts of dimethyl phthalate and 2 parts each of Indalone and Rutgers 6-12. We have tested a number of these repellents against several species of mosquitoes in the Northwest and believe a mixture is superior to the same materials used alone.

These materials can also be sprayed lightly on field garments (fig. 25) to make them repellent for several days (*127*).

FIGURE 25.—Work clothing being sprayed with a repellent to keep mosquitoes from biting through.

Two repellents recently recommended for military use (*159*) are (1) 6 parts of dimethyl phthalate, 2 parts each of Indalone and Rutgers 6-12, and 4 parts of the *n*-propyl ester of N, N-diethylsuccinamic acid; and (2) 6 parts of dimethyl phthalate, 2 parts each of dimethyl carbate and Indalone.

Since the repellents are solvents for paints, varnishes, and plastics such as watch crystals, nylon fabrics, and fountain pens, they should be used with caution. Care should be taken not to apply them too liberally on the forehead, as they will sting if they get into the eyes.

SPACE SPRAYS

Protection against mosquitoes can be obtained with space sprays. Practically all the commercial fly sprays containing pyrethrum, DDT, methoxychlor, certain organic thiocyanates, or lindane are safe and effective when used as directed on the label. Their proper application with a hand sprayer will quickly kill any mosquito indoors.

A 1-pound aerosol bomb is a handy device for killing adult mosquitoes in homes (fig. 26) or

FIGURE 26.—Using an aerosol bomb to kill mosquitoes within a home.

when on camping trips (fig. 27) and when traveling from place to place during the mosquito season. A few seconds' release of the aerosol will kill all mosquito species in an ordinary-sized room, tent, or trailer. It is not hazardous to humans if used as directed on the container. An aerosol formula much in use contains 0.4 percent of pyrethrins, 1.6 percent of refined kerosene, 3 percent of DDT, 5 percent of cyclohexanone, 5 percent of motor oil (A.A.E. 10), and 85 percent of Freon-12. Many modified formulas containing pyrethrins, allethrin, DDT, methoxychlor, and synergists are now available. A recently recommended aerosol formula contains 2 percent of DDT, 0.6 percent of allethrin, 5 percent of alkylated naphthalene, 7.4 percent of deodorized kerosene, and 42.5 percent each of Freon-11 and Freon-12.

FIGURE 27.—Using an aerosol bomb to kill mosquitoes in a pup tent.

Mechanically generated aerosols, fogs, mists, sprays, and smokes are now widely used out of doors. Many home owners, small-fruit farmers, and resort managers reduce mosquito annoyance to a minimum with these new devices. The best results are obtained when the work is done by experts such as mosquito-abatement superintendents or licensed pest-control operators. DDT-oil solutions can be used for this purpose but some prefer a pyrethrum-allethrin mixture because of its rapid action against mosquitoes and low toxicity to warm-blooded animals. The New Jersey mosquito larvicide (*34*) (see page 37) is also used as a space spray against adult mosquitoes out of doors at the rate of 15 to 25 gallons per acre.

Space sprays are effective for only a few hours, but have been used very successfully for outdoor social functions and picnics, and in and about amusement centers. Where practical to treat late each afternoon, this is an excellent way of gaining relief from annoyance, even though large numbers of mosquitoes are in the neighborhood. Fruit pickers and lumber and road crews also benefit from their use.

The new insecticides, such as BHC, lindane, chlordane, aldrin, and dieldrin, are also effective as space sprays, but these materials are highly toxic and can harm those using them, as well as those living within the treated areas. We must, therefore, caution against their use by uninformed and untrained persons. For outdoor space spraying in the Northwest, a 5-percent DDT emulsion, oil solution, or the New Jersey larvicide is recommended until additional information is obtained on the other materials.

The use of aircraft is an economical and safe way to disperse sprays over large areas to kill adult mosquitoes (*3*). An oil solution containing 5 to 20 percent of DDT and from 10 to 20 percent of a heavy oil (S.A.E. 30 to 50) in kerosene is an excellent formula for use by aircraft. Larger pay loads may be obtained by using a concentrate containing 25 percent of DDT, 10 percent of a wetting agent (such as Triton X-100 or equal parts of Span 20 and Tween 20), and 65 percent of xylene. Both the oil solution and the concentrate are applied at the same dosage of 0.1 to 0.2 pound of DDT per acre. All applications from aircraft should be directed by specialists and trained pilots. DDT concentrates should not be used over water where they would be hazardous to fish.

RESIDUAL SPRAYS

The stability, or long-time residual effectiveness, of DDT makes it possible to apply a spray on the interior surfaces of homes to kill mosquitoes that come in contact with these surfaces for several months (fig. 28). This method is particularly adapted to control of *Anopheles* mosquitoes, because of their habit of entering homes and other buildings, but it can also be used against *Culex pipiens* and *tarsalis* and some of the house-frequenting *Aedes* in the Northwest. DDT residual sprays for use within buildings

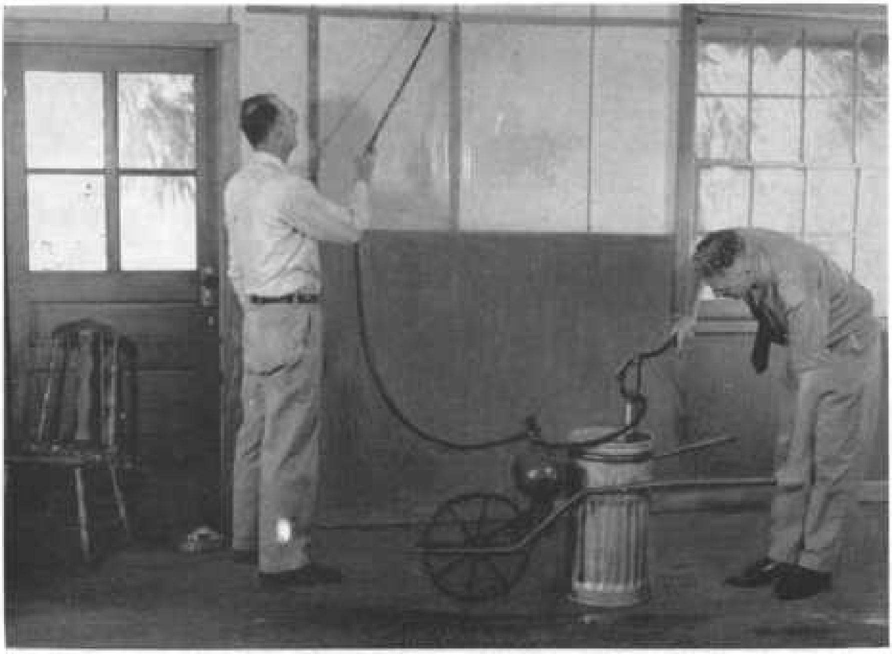


FIGURE 28.—Applying a DDT residual spray to the inside of a building to kill mosquitoes.

FIGURE 29.—Applying a DDT residual spray to vegetation to control mountain mosquitoes.

should contain 5 percent of DDT. An oil solution or emulsion, applied at the rate of about 1 gallon per 1,000 square feet, is preferred.

The spraying of all vegetation to a height of about 10 feet (fig. 29), as well as the surfaces of the buildings and the screens, to leave a residue of DDT where the mosquitoes rest will reduce mosquito annoyance in mountain camps (*66*). Applications of 2 to 3 pounds of DDT per acre have given good control for 10 days and sometimes for as long as 45 days. If the area to be protected is surrounded by extensive breeding areas, enough mosquitoes may fly into the treated areas to be annoying for 2 hours at dusk, but they will be killed later as they settle on the treated foliage. Emulsifiable concentrates are preferred for use in mist blowers and either emulsifiable concentrates or wettable powders for use in orchard sprayers. Water is added to give a 5- to 10-percent emulsion or a 2.5-percent wettable-powder suspension.

A dosage of 1½ pounds of lindane per acre gives about the same control as 2 pounds of DDT. Space sprays containing 0.2 to 0.4 percent of pyrethrins or allethrin applied at dusk will give excellent control when used in conjunction with the heavier residual spray.

CONTROL OF RESISTANT MOSQUITOES

The only known mosquito vector of disease that appears to have developed a high resistance to insecticides on the West Coast is *Culex tarsalis* in California. Up to the end of 1951 no resistance by *tarsalis* had been observed in the Northwest. While no specific recommendations are made for the Northwest, if resistance develops toxaphene, lindane, aldrin, heptachlor, dieldrin, chlordane, EPN, NPD, or malathon may be considered for use.

EQUIPMENT FOR APPLYING INSECTICIDES

Hand sprayers of the flit-gun type are satisfactory for spraying small puddles to kill larvae or for use indoors against adult mosquitoes. Aerosol bombs are best for applying space sprays within enclosures. Areas of an acre or more can be treated with a 3- or 4-gallon compressed-air sprayer or knapsack sprayer (*143*). Paint-type sprayers, which produce an atomized spray, can also be used in such places.

Power equipment of various types is used in extensive lowlands and marshes. This equipment includes orchard-type sprayers, mist blowers, heat-generated aerosol and fog machines, and devices attached to the exhaust of trucks or jeeps (*48, 108*).

Aircraft (*3*) is both effective and economical for treating large areas to kill both larvae and adults (fig. 30). Excellent results have been obtained with small aircraft over extensive floodwater lowlands along the Columbia River and in large irrigated sections. Most commercial aircraft operators can be relied on to do an effective and safe job.

NATURAL ENEMIES OF MOSQUITOES

Many insects, fishes, birds, and other organisms prey upon mosquito larvae (*64*). However, the only natural enemies of appreciable value in control programs are the minnows *Gambusia affinis* and *Fundulus* (*119*). These fish thrive best in warm parts of the country, but may establish some tolerance to freezing for short periods west of the Cascade Mountains. We have introduced *Gambusia* into the Northwest from California, but since, except

FIGURE 30.—An airplane with a breaker-bar sprayer mounted under each wing strut for treating large areas against mosquitoes.

for *dorsalis,* most of the important *Aedes* breeding grounds in this region are dry the greater part of the year, these fish are of little practical use here. However, they do keep *Culex* and *Culiseta* larvae in check in log ponds until the water becomes too polluted for the fish. They can be used also in permanent ponds and ornamental pools inhabited by *Anopheles* and *Culex tarsalis.*

Rarely we have observed *Planaria maculata* Lindy, a flat worm 15 mm. long, feeding on larvae in the laboratory. In restricted quarters these worms easily captured the larvae by wavering about the container. After a larva was captured it appeared unable to release itself, even with some assistance from the observer. In our limited observations each worm devoured one to two larvae per day.

Adult mosquitoes have a number of natural enemies, such as certain birds, bats, and predaceous insects (*65*). Undoubtedly swallows, some night-flying birds, bats, dragonflies, and damsel flies eat large numbers, but they seem to have little effect in reducing mosquito populations.

KEYS AND NOTES FOR IDENTIFYING THE MOSQUITOES OF THE NORTHWEST

The 39 species of mosquitoes found in the Northwestern States belong to 5 genera. Keys for their determination have been based on those found in the literature (*2, 22, 24, 35, 37, 63*). In a number of species new characters which facilitate determination have been found. Only the more important characters for each species have been included in this section, and synonyms of recent date are given.

The taxonomic characters used for identifying the *Aedes* mosquitoes in the Northwest are shown in figures 31 to 35.

KEY TO GENERA

ADULTS

1. Scutellum trilobed with marginal setae on the lobes only; palpi (in females) much shorter than the proboscis 2
   Scutellum crescent-shaped with marginal setae evenly distributed; palpi of males and females almost as long as proboscis .... *Anopheles*
2. Postspiracular bristles present .... *Aedes*
   Postspiracular bristles absent 3
3. Spiracular bristles present .... *Culiseta*
   Spiracular bristles absent 4
4. Wing scales broad, pale, and dark-mixed .... *Mansonia*
   Wing scales narrow or slightly broadened all dark .... *Culex*

LARVAE

1. Eighth segment without a dorsal siphon or respiratory tube .... *Anopheles*
   Eighth segment with elongated siphon or respiratory tube 2
2. Distal half of tube attenuated with saw-tooth projection at tip for piercing purposes; without pecten teeth .... *Mansonia*
   Air tube cylindrical and elongated 3
3. Air tube with siphonal tufts at base .... *Culiseta*
   Air tube with tufts within the pecten teeth or distal to them 4
4. Air tube with several pairs of tufts extending from pecten teeth to end of tube .... *Culex*
   Air tube with only one pair of tufts distal to pecten teeth[2] .... *Aedes*

[2] *Aedes trichurus* has a small tuft on the dorsal and one on the lateral surface of the air tube.

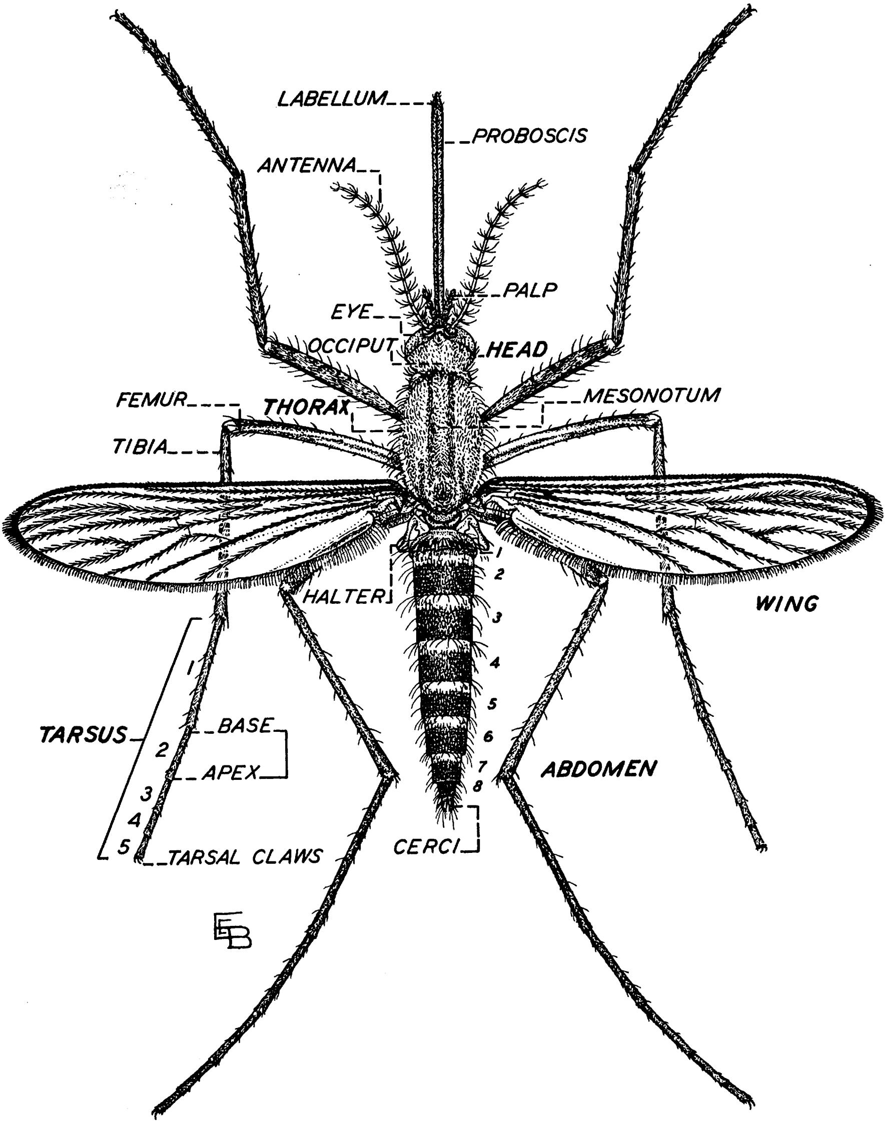


FIGURE 31.—Taxonomic characters used in identifying adult mosquitoes in the Northwest. *Aedes hexodontus.*

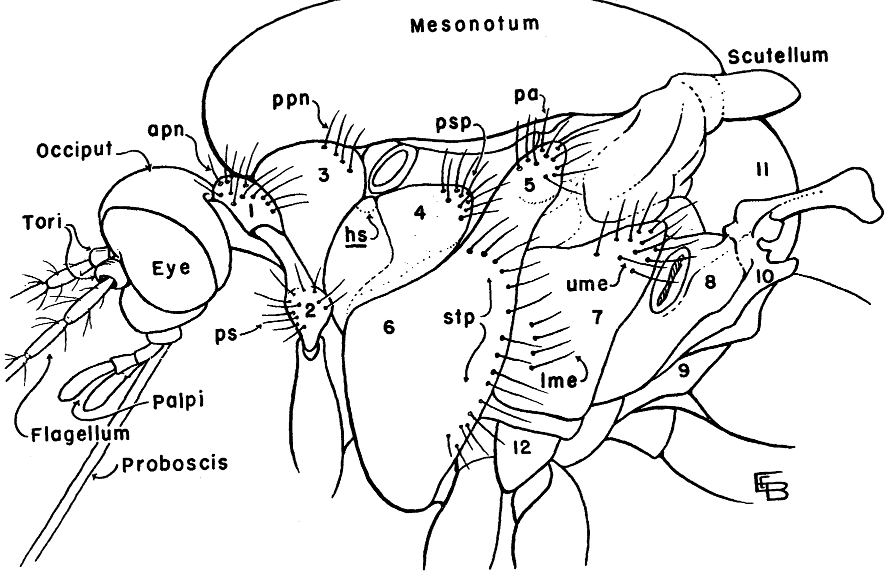


FIGURE 32.—Lateral view of *Aedes* head and thorax. *hs*, Hypostigial spot of scales. Sclerites of the thorax: 1,anterior pronotum; 2, proepisternum; 3, postpronotum; 4, mesanepisternum; 5, prealar, area; 6, sternopleuron; 7, mesepimeron; 8, metepisternum; 9, metasternum; 10, metepimeron; 11, postnotum; 12, meron. Setae: *apn;* anterior pronotal; *ps*, proepisternal; *ppn*, postpronotal; *psp*, postspiracular; *pa*, prealar; *st*, sternopleural; *ume*, upper mesepimeral; *lme*, lower mesepimeral.

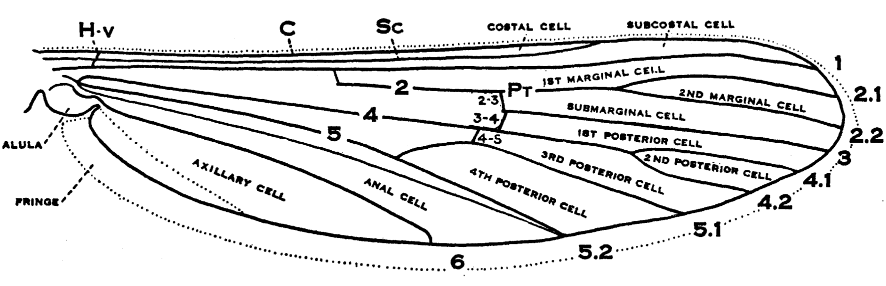


FIGURE 33.—Wing of *Aedes* mosquito, illustrating venation (modified from Ross and Roberts *120*). *H-v*, humeral cross-vein; *C*, costa; *Sc*, subcosta; *Pt*, petiole of vein 2; 1, 2.1, 2.2, 3, 4.1, 4.2, 5.1, 5.2, and 6, numbered longitudinal veins and their branches.

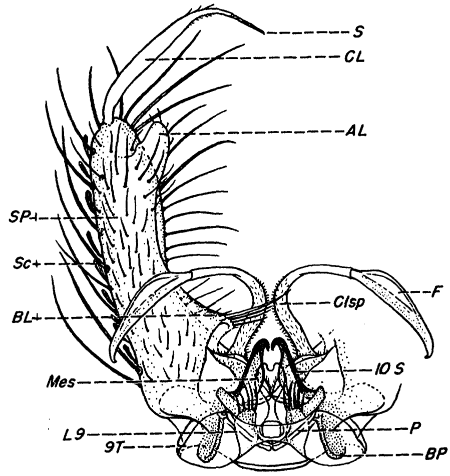


FIGURE 34.—Male genitalia of *Aedes cataphylla*, dorsal view, showing parts: *SP*, side piece; *Sc*, scale; *BL*, basal lobe; Mes, mesosome; *L9*, lobe of ninth tergite; 9T ninth tergite; *S*, spine of clasper; *CL*, clasper; *AL*, apical lobe; *F*, filament of claspette; *Clsp*, claspette; *10S*, tenth sternite; *P*, paramere; *BP*, basal plate,

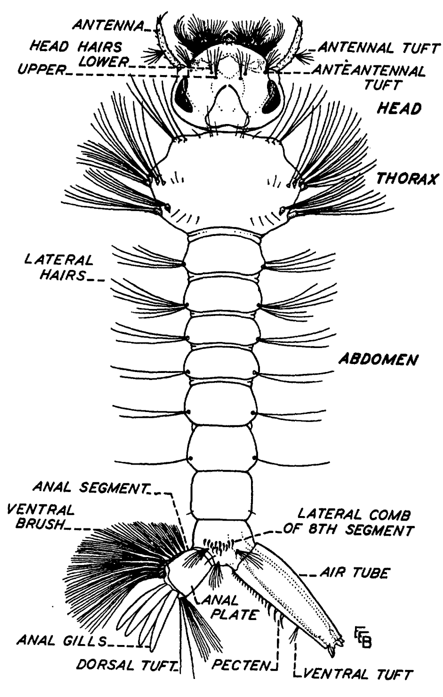


FIGURE 35.—Larval characters used in identifying mosquito larvae of the Northwest.

Genus ANOPHELES Meigen

KEY TO SPECIES

Adults

1. Wings with yellowish-white spots on the costal margin 2
   Wings without spots on the costal margin 3
2. Palpi white-banded; wings with pale spots on the forks and on the stem of vein 5 .... *pseudopunctipennis franciscanus*
   Palpi unbanded; wing scales on vein 5 dark .... *punctipennis*
3. Wings with patch of silvery or bronze-colored scales on the apex and heavy dark patches of scales on the veins .... *occidentalis*
   Wings dark scaled at the apex, the patches on the veins not very pronounced .... *freeborni*

Male Genitalia

1. Claspette with dorsal lobe bearing 2 or 3 broad leaflets; mesosome with very delicate leaflets .... *pseudopunctipennis franciscanus*
   Claspette with dorsal lobe bearing 2 or 3 sharp spines; mesosome with well-developed leaflets 2
2. Claspettes abruptly conical .... *punctipennis*
   Claspette lobe rounded 3
3. Claspers with dense patch of small hairs at the base; lobes of the ninth tergite short and broad .... *occidentalis*
   Claspers with patch of scattered hairs at the base; lobes of the ninth tergite long and slender .... *freeborni*

Larvae

1. Both inner and outer anterior clypeal hairs single .... *pseudopunctipennis franciscanus*
   Outer anterior clypeal hairs branched 2
2. Antepalmate hair of abdominal segments 4 and 5 one-branched; postclypeal hair multiple .... *occidentalis*
   Antepalmate hair of abdominal segments 4 and 5 usually two-branched; postclypeal hair bifurcate at middle to base; frontoclypeus with a spotted pattern .... *freeborni*
   Antepalmate hairs of segments 4 and 5 usually three-branched; postclypeal hairs bifurcated from insertion point and frontoclypeal banded .... *punctipennis*[3]

ANOPHELES FREEBORNI Aitken

Anopheles maculipennis freeborni Aitken, Pan-Pacific Ent. 15: 192. 1939.

Anopheles freeborni King and Bradley, Human Malaria, pp. 65, 75. 1941.

Female.—Palpi as long as proboscis, dark brown. Mesonotum with a pruinose gray stripe bordered by dark bands, the median stripe with hair-like yellowish scales and a small tuft of whiter scales anteriorly. Wing scales dark brown and aggregated into spots at the junction of the first and second veins, the forks of the second and fourth, and at the cross veins. Legs black, the apices of the femora and tibia with pale-yellowish scales.

Male genitalia (fig. 36, E).—Claspettes bilobed, with 2 (sometimes 3) spines on ventral lobe and usually with 2 spines on dorsal lobe. Mesosome with four pairs of nonserrated leaflets. Ninth tergite with slightly shortened, broadened lobes. Claspers with bases covered with a dense patch of nonpapillated hairs.

[3] These larvae are difficult to separate from those of *freeborni*.

Larva.—The larvae of this species are very similar to those of *punctipennis*. Minor variations are given in the key.

Distribution, biology, and importance.—*Anopheles freeborni* is widely distributed in open and wooded country throughout the Northwestern States (*2*). It occurs in clean, sunny water, wherever suitable breeding places are found. Comparatively large populations develop in irrigated areas in the Yakima Valley in Washington and in the vicinity of Scappoose, Prineville, and Klamath Agency, Oreg. It has been found in abundance in the irrigated section of west-central Idaho. This species, the most important malaria carrier in the Western States, is prevalent also in the Willamette Valley in Oregon, where most of the malaria cases in this region have occurred. Western equine encephalomyelitis has been isolated from it in nature.

The females hibernate in root cellars, barns, outbuildings, and other sheltered locations. They emerge from these places by the latter part of February in the warmer parts of this region, but few eggs are laid before April or May. Larvae have been taken along the margins of rivers, creeks, and irrigation ditches and in ponds, sloughs, and roadside ditches from early in May until frost. Apparently the females mate before going into hibernation, because the males do not overwinter. The adults are sometimes found in fairly large numbers early in September. It is frequently associated with *Culex tarsalis*.

ANOPHELES OCCIDENTALIS (Dyar and Knab)

Anopheles occidentalis Dyar and Knab, Biol. Soc. Wash. Proc. 19: 159. 1906.

Female.—Similar to *freeborni*, except for slightly more contrasting stripes on the mesonotum, darker and more pronounced wing spots, and the presence of a spot of pale scales at the apex of the wing.

Male genitalia (fig. 36, F).—Similar to genitalia of *freeborni*, except for the smaller number of hairs on the base of the claspers and the slightly longer and more slender lobes of the ninth tergite.

Larva.—Only minor characters are available for separating the larvae of this species from *freeborni* and *punctipennis*. The postclypeal hairs have 2 to 3 stout branches near the middle. The frontoclypeal is banded and the antepalmate hairs on segments 4 and 5 are usually single and unbranched.

Rozeboom (*123*), in recent work in Montana on anophelines, claims that the mosquito east of the Rocky Mountains hitherto called *occidentalis* is *earlei*. An additional character he has used to differentiate between the two species is that the egg of *earlei* is barred whereas that of *occidentalis* is plain.

Distribution, biology, and importance.—This mosquito has been found in small numbers in southern Oregon, in the mountains of northern Washington and Idaho, and near the southeastern border of Idaho. The larvae have been found alone and also associated with the other three species of *Anopheles* in this region. They have also been taken with *Culex tarsalis* and *Culiseta inornata*. Breeding places usually contain moss and algae, but larvae have been observed in open grassy pools.

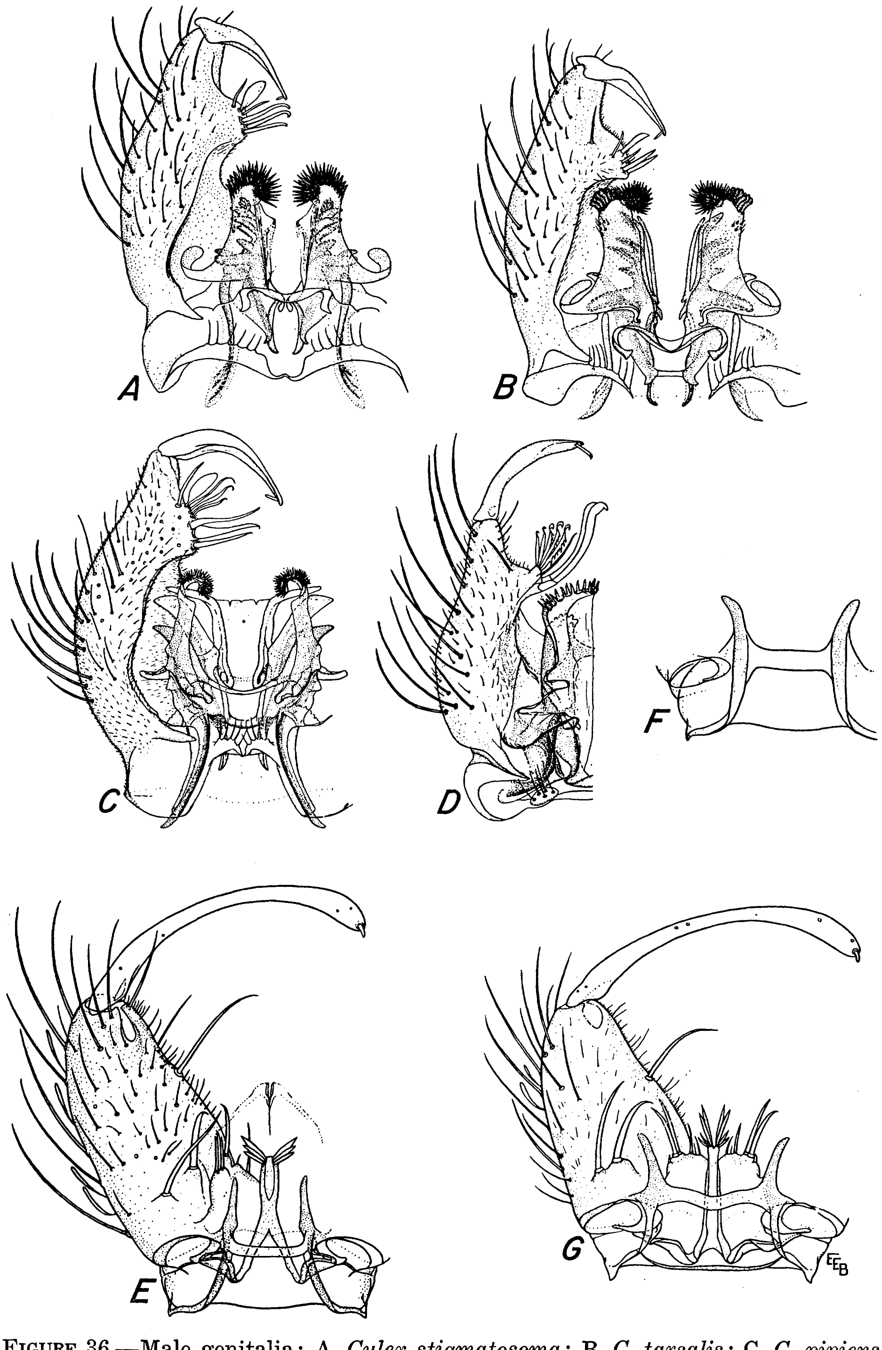


FIGURE 36.—Male genitalia: A, *Culex stigmatosoma;* B, *C. tarsalis;* C, *C. pipiens;* D, *C. territans;* E, *Anopheles freeborni;* F, *A. occidentalis*, lobes of ninth tergite; G, *A. punctipennis.*

ANOPHELES PSEUDOPUNCTIPENNIS FRANCISCANUS McCracken

Anopheles franciscanus McCracken, Ent. News 15: 12. 1904.

Anopheles pseudopunctipennis var. *franciscanus* King and Bradley, Human Malaria, 65 pp. 1941.

Anopheles pseudopunctipennis franciscanus Aitken, Calif. Univ. Pubs. Ent. 7 (11): 327. 1945.

Female.—Palpi as long as proboscis, black-scaled with white rings at the joints of the apical end of the two preceding segments. Mesonotum with a median pruinose gray stripe bordered by dark bands; the median stripe with hairlike gray scales and a tuft of whiter ones anteriorly. Wing scales black, with yellowish-white scales forming spots as follows: Costa and subcosta with two on the apical half, the subcosta with two additional ones on the basal half; second vein with a small one near the cross vein and a small one before the apex of the upper branch; third vein with a small one at the base and a large one in the middle; fourth vein with a small one at the cross vein and a small one at the apices of the forks; fifth vein with a small one at the base and a large one extending into the lower fork, small ones at the apices of the forks and a small one near the middle of the upper fork; sixth vein with a long spot at the base. Legs black, the tips of the femora and tibia with pale-yellowish scales.

Male genitalia.—Claspette bilobed with 2 slender spines on the ventral lobe and 2 or 3 broad, leaflike spines on the dorsal lobe. Mesosome with very small nonserrated leaflets. Ninth tergite with low conical processes.

Larva.—Both the inner and outer clypeal hairs of the larvae of this species are single and unbranched, and the postclypeal hairs are also single and long. The abdominal palmate hairs on segments 3 to 7 are well-developed and serrate. In the race *franciscanus* the posterior spiracular plates are not developed into "tails," but are rounded.

Distribution, biology, and importance.—This species has been found rarely in the extreme southwestern part of Oregon and in the vicinity of Medford. The larvae are usually associated with *freeborni* along streams in sunny pools containing algae. Very little information is available regarding its habits in the Northwest.

ANOPHELES PUNCTIPENNIS (Say)

Culex punctipennis Say, Acad. Nat. Sci. Phila. Jour. 3: 9. 1823.

Anopheles perplexens Ludlow, Canad. Ent. 39: 267. 1907.

Female.—Palpi as long as the proboscis, dark brown. Mesonotum with pruinose gray stripe bordered by dark bands; the median stripe with hairlike gray scales and a tuft of whiter ones anteriorly. Wing scales black, with yellow ones forming spots as follows: A large one on the basal third of the costal margin, which involves the base of the second vein before the fork; a smaller one on the apex of the wing, which involves both forks of the second vein; third vein with a spot at apex or near the middle or completely dark-scaled; fourth vein with two spots on the base and one spot on each fork; sixth vein with one spot in the middle. Legs black, the tips of the femora and tibia with pale-yellowish scales.

Male genitalia (fig. 36, G).—Claspettes bilobed, usually with one large outer spine and an inner more slender spine on the ventral lobe, and 2 spines on the dorsal lobe. (The number of spines is highly variable.) Mesosome with well-developed nonserrated leaflets. Ninth tergite with broad, normal lobes.

Larva.—Head longer than wide. Posterior clypeal hairs usually bifurcate to the base, inner clypeal hairs sinlge, unbranched, and set close together. Frontoclypeal sclerite pale-banded. Abdomen with palmate tufts on segments 3 to 7 and occasionally a small one on segment 2. Either 2 or 3 antepalmate hairs on segments 4 and 5. Anal segment longer than wide, and dorsal plate with a long, single lateral hair. Anal gills as long as segment and bluntly pointed.

Distribution, biology, and importance.—This is a common species throughout Washington, the northern half of Idaho, and west of the Cascade Mountains in Oregon. The larvae are usually associated with *freeborni* in clean shaded pools. *A. punctipennis* is believed to be of little importance as a malaria carrier.

Genus AEDES Meigen

KEY TO SPECIES

Adults

1.	Tarsal segments ringed with white	2
	Tarsal segments not ringed with white	11
2.	Tarsi with white rings at both ends of the segments	3
	Tarsi with white rings at base of segments only	6
3.	Wing scales black and white intermingled	4
	Wing scales uniformly dark or with some white scales on anterior vein	5
4.	Wing scales uniformly mottled black and white	*campestris*
	Wing scales not uniformly mottled; third vein with more dark scales than second and fourth	*dorsalis*
5.	Mesonotum golden brown; base of costa dark scaled	*canadensis*
	Mesonotum with variable pattern of pale yellowish and dark spots; base of costa with white scales	*varipalpus*
6.	Proboscis of female ringed with white	*nigromaculis*
	Proboscis of female not ringed with white	7
7.	Basal white rings of tarsal segments narrow (mesonotum uniformly brown; abdominal pale bands indented centrally)	*vexans*
	Basal white rings of tarsal segments broad, especially on the hind legs	8
8.	Abdomen without bands and clothed with yellow scales; (mesonotum yellowish brown with darker median area)	*flavescens*
	Abdomen dark-scaled with white or gray dorsal bands	9
9.	Lower mesepimeral bristles absent (mesonotum with variable pattern of brown and white, on completely reddish-brown scale)	*excrucians*
	... *fitchii*	(in part)
	Lower mesepimeral bristles present	10
10.	Torus without scales on dorsal half; 1 to 5 lower mesepimeral bristles	*increpitus*
	Torus with white scales on dorsal half; lower mesepimeral bristles 0 to 4 but rarely more than 2 ... *fitchii*	(in part)
11.	Wing scales distinctly bicolored	12
	Wing scales uniformly dark or nearly so	13
12.	Wing scales pale and dark intermixed, the dark predominating; lower mesepimeral bristles present	*niphadopsis*
	Wing veins alternating black and white; lower mesepimeral bristles absent	*idahoensis*
13.	Mesonotum without lines or stripes	14
	Mesonotum with lines or stripes	18
14.	Lower mesepimeral bristles absent	15
	Lower mesepimeral bristles present	16

15. Mesonotum uniformly brown; abdomen with continuous lateral white line .... *cinereus*
Mesonotum brown with margin of yellowish scales; abdomen with continuous lateral white line .... *ventrovittis*
16. Torus with integument of outer side yellow to light brown or darker; mesonotum uniformly brown; or rarely with indications of median brown lines .... *intrudens*
Torus with integument of outer side dark brown or black 17
17. Mesonotum gray around the sides with golden-brown scales in the middle, which sometimes show faint dark lines .... *cataphylla*
Mesonotum with dark-brown or bronzy scales, sometimes with a pair of lighter spots centrally .... *nearcticus*
18. Lower mesepimeral bristles absent; mesonotum with two golden brown stripes, with or without a faint pale median line .... *sticticus*
Lower mesepimeral bristles present 19
19. Hypostigial spot of few to many white scales 20
Hypostigial spot absent 21
20. Mesonotum with paired brown lines separated by a double line of yellowish scales with a narrow bare median line between them; torus with integument of outer side dark brown or black .... *pullatus*
Mesonotum with a median brown stripe expanded in width behind the middle; torus with the integument of the outer side usually yellow to light brown .... *trichurus, impiger* (in part)
21. Mesonotum yellow or rarely gray, with paired dark-brown lines or variable pattern; integument of tori varying from yellow to black .... *communis*[4]
Mesonotum yellow or rarely gray, with paired dark-brown stripes narrowed at the back and extending to the scutellum .... *pionips*[4]
Mesonotum with median brown stripe, paired brown stripes or variable pattern; margin grayish white .... *impiger*
Mesonotum golden brown with paired dark-brown stripes which are sometimes joined; integument of tori black or dark brown *hexodontus*[5]
Mesonotum yellowish to light golden brown with dark-brown stripes and posterior half lines .... *aboriginis*[6]

Male Genitalia

1. Clasper inserted before the apex of side piece; unequally bifurcate at the base .... *cinereus*
Clasper not inserted before the apex of the side piece; not branched at the base 2
2. Clasper broad and flat throughout its length with subapical spine; claspette a setiferous knob without a filament .... *vexans*
Clasper tapered to the apex with apical spine; claspette with a filament 3
3. Side pieces without distinct apical lobe 4
Side pieces with both apical and basal lobes 5
4. Side piece expanded at the base; the basal lobe narrowly elongate and clothed with long setae; a secondary area with short setae beside it .... *varipalpus*
Side piece not expanded at the base; the basal lobe a small elevated area with relatively short setae .... *nigromaculis*
5. Filament of claspette with transverse ridges; (small secondary lobe near basal lobe with two long spines) .... *trichurus*
Filament of claspette without transverse ridges 6
6. Apical lobe with short appressed setae 7
Apical lobe with long hairs or nearly bare 8
7. Basal lobe with portion extending toward apex of side piece, semidetached .... *sticticus, idahoensis, ventrovittis*
Basal lobe with portion extending toward apex of side piece, not semidetached .... *hexodontus, aboriginis*

[4] Base of costa and sometimes vein 1 white-scaled in 75 to 95 percent of the specimens.
[5] Base of costa white-scaled in about 95 percent of specimens.
[6] Base of costa black-scaled in 90 to 100 percent of specimens.

8. Basal lobe without spines 9
   Basal lobes with spines 11
9. Filament of claspette narrow and of approximately equal width... *canadensis*
   Filament of claspette expanding along one margin 10
10. Basal lobe flat, rugose, setose, and extending to apical lobe .... *excrucians*
    Basal lobe not extending beyond middle of side piece .... *increpitus*
11. Basal lobe with one spine 12
    Basal lobe with two or more spines 17
12. Basal lobe extending almost to the apical lobe .... *flavescens*
    Basal lobe a small area at the base of the side piece 13
13. Apical lobe of the side piece nearly bare 14
    Apical lobe distinctly setose 15
14. Filament of the claspette expanded into a sharp projection near the base .... *impiger*
    Filament of claspette expanded in a gradual curve near the base .... *niphadopsis, cataphylla*
15. Filament of the claspette sickle-shaped with a small notch at the base .... *fitchii*
    Filament of the claspette not notched at the base 16
16. Basal lobe quadrilateral in outline .... *communis, pionips*
    Basal lobe cone- or wedge-shaped .... *nearcticus*
17. Claspettes with sharp projections or right angle bends at the middle of the inner margin 18
    Claspettes without sharp projections or bends at the middle of the inner margin 19
18. Claspette with rounded angle at the middle .... *pullatus*
    Claspette with sharp projection ending in a stout setae at the middle .... *intrudens*
19. Filament of claspette gradually expanded in a circular shape from the base to the middle .... *campestris*
    Filament of claspette a narrow basal stem which expands broadly near the middle .... *dorsalis*

Larvae

1. Pecten on air tube with detached teeth outwardly 2
   Pecten on air tube without detached teeth outwardly 11
2. Air tube with tufts within pecten 3
   Air tube with all tufts outside pecten and distal to it 4
3. Air tube with tuft within the pecten and several rows of tufts distal to pecten .... *trichurus*
   Air tube with tuft between evenly spaced pecten teeth and detached teeth .... *cataphylla*
4. Anal segment completely ringed by plate .... *nigromaculis*
   Anal segment not completely ringed by plate 5
5. Both pairs of head hairs usually single 6
   Both pairs of head hairs multiple 8
6. Air tube about four times as long as wide; gills small or budlike... *niphadopsis*
   Air tube about 2½ x 1; gills pointed and as long or longer than segment 7
7. Comb on eighth segment 6 to 9 scales, with basal spinules.......... *ventrovittis*
   Comb on eighth segment 9 to 20 scales, without basal spinules.... *idahoensis*
8. Both pairs of head hairs, 5 or more, tufts set close together; gills very long and pointed .... *cinereus*
   Upper head hairs 4, lower 2 or 3 (anal gills short and bluntly pointed) .... *intrudens*
   Lower hairs double, upper usually double or triple 9
9. Comb on eighth segment 10 to 25 scales in irregular row (tuft of small fine hairs on air tube set close to end of pecten teeth).... *vexans*
   Comb on eighth segment 40 or more scales in triangular patch ... 10
10. Air tube 4 x 1, pecten not reaching middle of tube; lateral abdominal hairs usually double on segments 1 and 2 and single on 3 to 6... *excrucians*
    Air tube 3 x 1, with pecten reaching the middle; lateral abdominal hairs double on segments 1 to 6 .... *flavescens*
11. Anal segment ringed by the plate .... *hexodontus*
    Anal segment not ringed by the plate 12

12. Anal gills long, enlarged and spatulate (antennae slender, without spines, and with single hairs in middle) .... *varipalpus*
    Gills and antenna normal 13
13. Both pairs of head hairs single 14
    Upper head hairs multiple, lower usually multiple 17
14. Comb on eighth segment has many scales in triangular patch...... 15
    Comb on eighth segment has 10 to 25 scales in irregular rows.... 16
15. Anal gills pointed and two to three times length of segment; lateral abdominal hairs double on segments 1 and 5 and single on 6 .... *communis*
    Anal gills budlike or, if longer, bluntly pointed and not so long as segment; lateral abdominal hairs triple on segments 1 and 2, double on the rest .... *dorsalis*
16. Comb on eighth segment, 8 to 14 scales; anal gills three to four times length of segment .... *nearcticus*
    Comb on eighth segment, 15 to 25 scales; gills slender and about as long as segment .... *impiger*
17. Air tube four or more times as long as wide .... *fitchii*
    Air tube never 4 x 1, usually 3 x 1 or less 18
18. Upper head hairs 5 to 8, lower 3 to 5 19
    Upper head hairs not more than 4, lower 1 to 3................ 21
19. Air tube stout 2½ x 1 with closely set pecten teeth to near middle; anal segment as long as wide .... *pionips*
    Air tube 3 x 1 with pecten teeth on basal one-third; anal segment longer than wide 20
20. Anal gills two or more times length of anal segment .... *pullatus*
    Anal gills only about as long as segment .... *canadensis*
21. Gills small and budlike; pecten on air tube extending two-thirds of its length, the last tooth sometimes slightly detached, a tuft near tip .... *campestris*
    Gills pointed, as long or longer than segment; pecten not extending beyond middle of segment 22
22. Head hairs, upper 3 to 4, lower 2 to 4 (lateral abdominal hairs, 1 or 2 long stout hairs) .... *aboriginis*
    Upper head hairs 2 to 3, lower 1 to 2 23
23. Anal segment broader than long; air tube stout 2½ x 1; anal gills considerably longer than segment .... *sticticus*
    Anal segment as long as broad; air tube 3 x 1; anal gills about as long as segment .... *increpitus*

AEDES CAMPESTRIS Dyar and Knab

Aedes campestris Dyar and Knab, N. Y. Ent. Soc. Jour. 15: 213. 1907.

Female. — Mesonotum yellowish-white with median brown stripe, the sides with a narrow brownish margin. Abdomen black with median white line, and apical and basal white bands forming small paired segmental dark areas. Wing scales pale and dark, evenly intermixed. Legs with dark and pale scales, tarsi dark with basal and apical white bands, except on last two segments of midtarsus and last three segments of fore tarsus.

Male genitalia (fig. 37, C).— Side pieces about three times as long as wide; apical lobe low convex with rather long setae; basal lobe rounded, slightly raised, and covered with many setae, a large spine and several long spinelike setae at the basal margin. Claspette hirsute with two or three small setae just below the apex, the filament narrowly and roundly expanded in a sickle shape.

Larva.—Antennae spinose. Upper head hairs multiple, lower 1 or 2. Comb on eighth segment with many scales in a triangular patch. Air tube about 3 x 1, tapering with pecten reaching two-

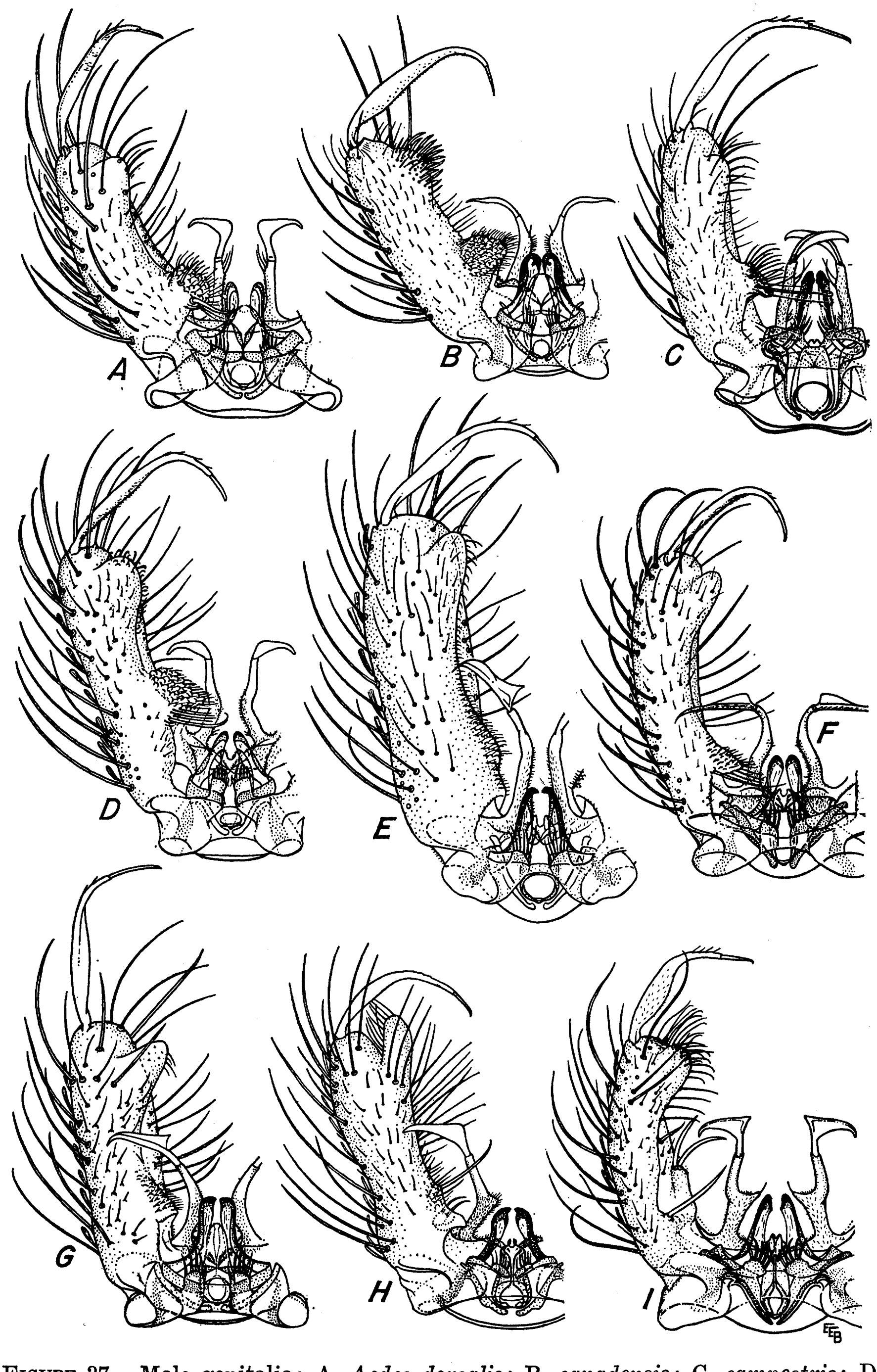


FIGURE 37.—Male genitalia: A, *Aedes dorsalis;* B, *canadensis;* C, *campestris;* D, *aboriginis;* E, *excrucians;* F, *nearcticus;* G, *increpitus;* H, *pullatus;* I, *intrudens.*

thirds of the distance to apex and a small tuft near the tip, the last tooth sometimes stouter and slightly detached. Anal segment as long as wide, anal plate reaching nearly to ventral line; gills small and budlike.

Distribution, biology, and importance.—This species has been found in only a few small areas in Oregon and Washington. The larvae develop in open, unshaded water and are sometimes associated with *dorsalis*. Correspondents report the eggs as very resistant to adverse conditions. It is an early-season species, the adults appearing in June. They will bite during the day, as well as during the hours of darkness. Rees (*109*) reports it flying 10 miles from its breeding place in Utah. It is of little importance in the region.

AEDES DORSALIS (Meigen)

Culex dorsalis Meigen, Syst. Bes. Bek. Eur. Zwei, Ins. 6: 242. 1830.

Aedes melanimon Dyar, Ins. Ins. Mens. 12: 126. 1924.

Female.—Mesonotum yellowish white with a median brown stripe, or with only a few brown scales medianly; posterior brown half lines and side lines may or may not be present. Abdomen with apical and basal white bands and complete or partial median white line; the last one or two segments may be entirely white-scaled. Wing scales black and white; the costa first, third, and fifth veins with more black scales than the others. Legs with dark and pale scales; tarsi dark with apical and basal white bands on all but last two segments of mid-tarsus and last three segments of fore tarsus.

Male genitalia (fig. 37, A).—Side pieces about three times as long as wide; apical lobe rounded, and somewhat shortened apically, the surface clothed with rather long setae; basal lobe prominent, slightly constricted at the base, and covered with short setae, a stout spine on the margin and a smaller adjacent spine. Claspette straight, hirsute, and constricted just before the apex, with 2 long and 1 short setae at the constriction, the filament broadly expanded in a rounded rectangular shape at the middle.

Larva.—Antennae spinose. Both pair of head hairs single. Abdomen stout with few hairs; lateral tufts triple on segments 1 and 2 and double on the rest. Comb on eighth segment with many scales in a triangular patch. Air tube tapering, about 3 x 1; pecten evenly spaced to near middle of the tube, with a multiple tuft set close to end of pecten. Anal segment slightly longer than wide; anal gills either budlike or, if longer, bluntly pointed and seldom as long as the segment.

Distribution, biology, and importance.—This is one of the most important and widely scattered pest mosquitoes in the Northwestern States. We have not found it in the northern half of Idaho. The larvae develop in open, sunny areas that are flooded by saline, alkaline, or fresh water. They thrive in water of high alkalinity. It is the only species that breeds in the salt marshes in this region and is one of the most abundant and troublesome species in irrigated meadows and in grasslands that are inundated by floodwater. *A. dorsalis* larvae are sometimes associated with those of *nigromaculis* and *campestris* in the more alkaline waters and with *vexans* in fresh water. Rees (*111*) reports that seven successive broods have been taken from the same locality during a single season, and that the eggs may remain viable for 2 or 3 years. The high temperatures in midsummer in the inland valleys cause the adults to emerge in about 5 days after the land has been flooded. It is a persistent biter, even in midday and will enter houses to obtain blood meals. It is very annoying to livestock. Adults are readily attracted to light traps and are strong fliers. Rees (*109*) has observed them 22 miles from their breeding grounds. Western equine encephalomyelitis and St. Louis encephalitis viruses have been isolated from this species in nature, and it has been demonstrated as an experimental vector for Japanese B and California encephalitis viruses.

AEDES CANADENSIS (Theobald)

Culex canadensis Theo., Mon. Culic. 2: 3. 1901.

Female. — Mesonotum reddish brown with pale-yellow scales around the margins. Abdomen black without basal white bands or with narrow indistinct ones; the sides with triangular white spots. Wing scales all dark. Legs black; hind and midtarsal segments apically and basally white-banded; fore tarsus banded on segments 1 and 2; last segment of hind leg entirely white-scaled.

Male genitalia (fig. 37, B).—Side pieces slightly more than twice as long as wide; apical lobe large, low, and broadly rounded with short bladelike setae; basal lobe long, with many short setae. Claspette cylindrical and setose, a larger seta before the apex; the filament narrow, linear, pointed, and slightly shorter than the stem.

Larva.—Antennae spinose. Upper head hairs 6 to 7, lower 4 to 5; lateral abdomen hairs usually double on segments 1 to 5 and single on 6. Comb on eighth segment with 25 to 40 scales in an irregular patch. Air tube 3 x 1; pecten even, reaching beyond one-third of tube, followed closely by tuft of 4 to 6 medium hairs. Anal segment longer than wide; anal gills pointed and about as long as the segment.

Distribution, biology, and importance.—This species breeds in woodland pools. It has not been taken in Oregon, but has been collected in large numbers in northern Idaho and has also been taken in Ferry, Okanogan, and Grant Counties, in Washington. It is the predominating species around Payette Lake in Idaho. The larvae can be found in temporary forest pools which are flooded by melting snow. They seem to prefer laying their eggs in depressions containing decaying leaves and other debris. We have also found a few at high elevations in open meadows. The species bites severely and is a considerable pest, especially in late afternoon in large wooded areas.

AEDES NIGROMACULIS (Ludlow)

Grabhamia nigromaculis Lud., Geo. Wash. Univ. Bul. 5: 85. 1907.

Female.—Proboscis of female ringed with white. Mesonotum with varying shades of yellowish scales, a broad median bronzy-brown stripe, and brown sides. Abdomen black with basal segmental bands and median stripe of yellowish scales; the lateral spots usually concolorous with the median stripe. Wing scales pale and dark, the dark predominating. Femora and tibiae partially pale-scaled; tarsi black with basal

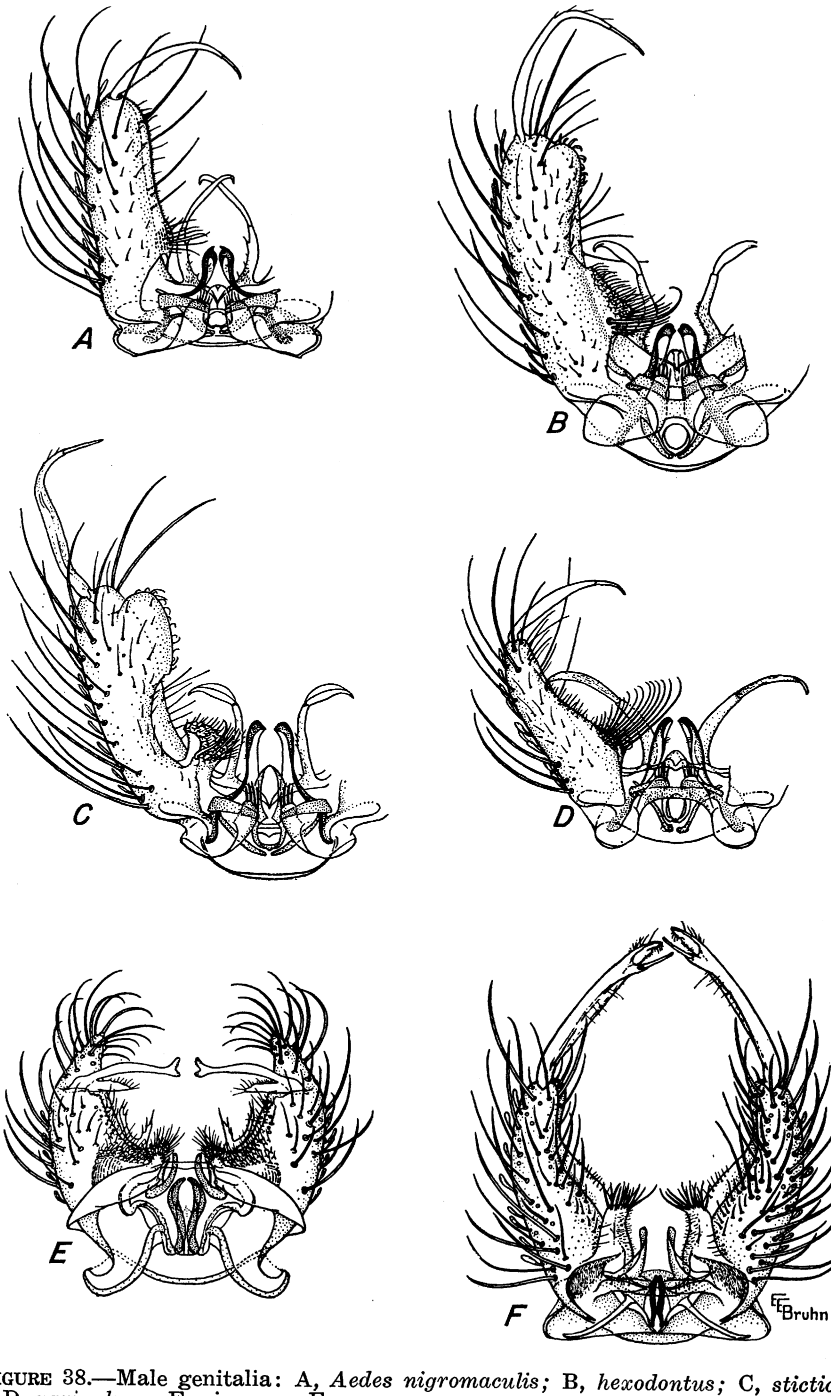


FIGURE 38.—Male genitalia: A, *Aedes nigromaculis;* B, *hexodontus;* C, *sticticus;* D, *varipalpus;* E, *cinereus;* F, *vexans.*

white bands; the last segment of the hind tarsus rarely all white, the white band on the first segment broadly extended by scattered white scales.

Male genitalia (fig. 38, A).—Side pieces twice as long as wide; apical lobe absent; basal lobe a small elevated area with many rather short setae. Claspette with a cylindrical stem and a short setae near the outer end; the filament narrow and as long as the stem.

Larva.—Both pairs of head hairs single and antennal tuft small. Comb on eighth segment with about 9 thornlike scales. Air tube 2 x 1; pecten extending well past the middle, with 3 stout detached teeth; a small tuft near the tip. Anal segment longer than wide and ringed by the plate. Anal gills pointed and longer than the segment.

Distribution, biology, and importance.—This species is found associated with *dorsalis, idahoensis,* and *vexans* in open irrigated or flooded meadows in prairie or open country. It has been found in only south-central Washington, but is more common in the semiarid plains of Oregon and Idaho. It is most numerous in the lower Payette River district of western Idaho. It is also an important pest in some other irrigated sections. It is a persistent daytime biter. Apparently it breeds continuously throughout the season and is associated frequently with *dorsalis.* This species is a strong flier. Experimentally it has transmitted western equine encephalomyelitis and St. Louis and Japanese B encephalitis viruses.

AEDES FLAVESCENS (Müller)

Culex flavescens Müller, Faun. Ins. Fried. p. 87. 1764.

Female.—Mesonotum yellowish to brown with a broad median stripe of slightly darker brown scales. Abdomen covered with dull-yellow scales or with a dark median line and sides partially black-scaled anteriorly. Wing with a mixture of black and yellow scales. Legs brown with a mixture of yellow scales; tarsi with broad basal white band.

Male genitalia (fig. 39, D).—Side pieces more than twice as long as wide; apical lobe prominent rounded with many setae; basal lobe a rugose, slightly elevated area with many setae, a stout spine and several long setae near the base, the lobe extending nearly to the base of the apical lobe. Claspette lightly hirsute with three stout setae on the inner margin of the base; the filament angularly expanded to a rounded point near the base.

Larva.—Upper head hairs usually 3 to 4, lower usually double. Lateral abdominal hairs double on segments 6 to 8. Comb on eighth segment with many long spinelike scales in a triangular patch. Air tube tapering, about 3 x 1; pecten reaching middle, with 2 detached teeth followed by a tuft of 4 to 6 hairs. Anal segment slightly longer than wide. Anal gills about as long as the segment.

Distribution, biology, and importance.—This is a typical plains species, and has been taken in limited numbers in widely separated places east of the Cascade Mountains, but it rarely occurs in sufficient numbers to be a serious pest. Larvae have been found in meadow pools and marshes in the vicinity of alkaline flats. It is a fierce day-time biter and attacks both man and beast. We have observed it biting in full sun and during a breeze of about 7 miles per hour. Hearle (*59*) has reported its life history.

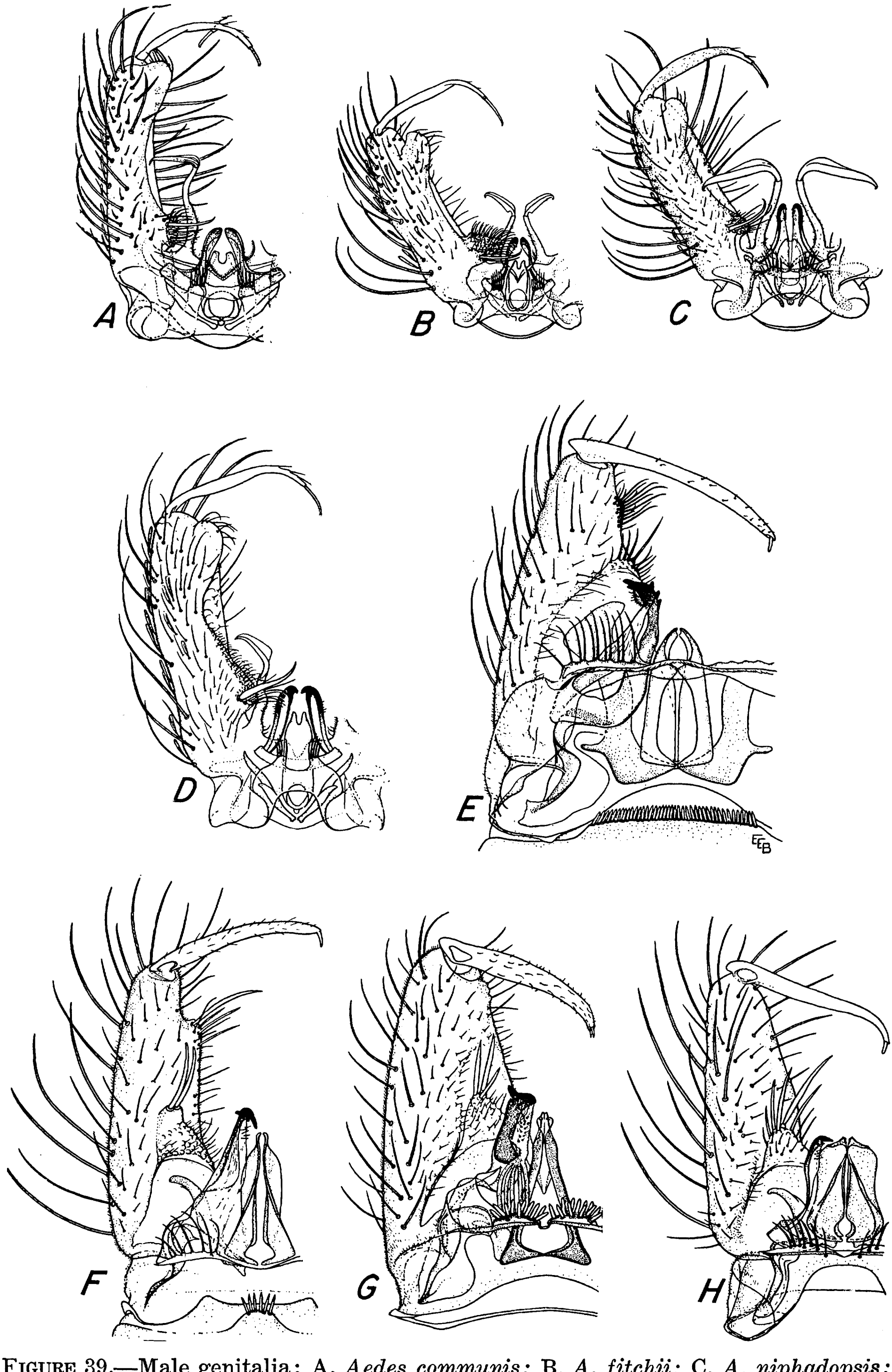


FIGURE 39.—Male genitalia: A, *Aedes communis;* B, *A. fitchii;* C, *A. niphadopsis;* D, *A. flavescens;* E, *Culiseta impatiens;* F, *C. incidens;* G, *C. inornata;* H, *C. morsitans.*

AEDES EXCRUCIANS (Walker)

Culex excrucians Wlkr., Ins. Saund., p. 429. 1856.
Aedes aloponotum Dyar, Ins. Ins. Mens. 5: 98. 1917.

Female.—Tori with inner surfaces predominately white-scaled. Mesonotum yellowish white with a median brown stripe, varied pattern of brown and white scales or completely reddish-brown scales. Mesepimeral bristles absent or rarely there may be one. Abdomen black with basal segmental white bands and frequently with scattered white scales. Wings predominantly dark-scaled with pale scales intermixed. Legs black with tarsal white bands broad on hind legs and usually absent on last segment of mid tarsus and last two segments of fore tarsus.

Male genitalia (fig. 37, E).—Side pieces about three times as long as wide; apical lobe prominent with small setae; basal lobe slightly raised, rugose, and extending to the base of the apical lobe, the surface covered with short setae. Claspette hirsute except at the apex; the filament angularly expanded to a sharp point near the base.

Larva.—Upper head hairs multiple, lower usually double. Lateral abdominal hairs long and stout, usually double on segments 1 and 2 and single on the rest. Comb on eighth segment with many scales in a triangular patch. Air tube slender, about 4 x 1; pecten not reaching the middle, with 2 to 3 large detached teeth; tuft with 4 to 6 large hairs. Anal segment longer than wide: plate extending about three-fourths of the distance down the side, and with a single long hair on the posterior angle. Anal gills pointed and slightly longer than the segment.

Distribution, biology, and importance.—This species is widely distributed at low elevations in mountainous areas in the Northwestern States and is found in both open and semiwooded areas. We found it in the Cascade Mountains and in Lake and Klamath Counties of Oregon, as well as through the wooded section of southern Idaho, but it is more abundant in northern Idaho and in Washington. The larvae have been taken also in roadside ditches bordered by brush, in potholes in open meadows, and in other temporary pools. It is sometimes associated with *fitchii* and *hexodontus*. The adults appear later than do those of many of the *Aedes*, sometimes not until July. The species is important only in local areas and then only for a short time.

AEDES FITCHII (Felt and Young)

Culex fitchii Felt and Young, Science (n.s.) 20: 312. 1904.

Female.—Torus with white scales on dorsal half. Mesonotum yellowish white to light brown, with a broad median brown stripe or variable pattern of brown and light scales. Wings dark-scaled, usually with an admixture of white scales along the costa. Mesepimeral bristles none to two, rarely three or four. Abdomen black with basal white bands, and sometimes with apical white scales which may extend into a median white line. Legs black, tarsi with basal white bands on all except the last two segments of fore tarsus and first segment of mid tarsus, the white bands broader on the hind legs.

Male genitalia (fig. 39, B).—Side pieces about three times as long as wide; apical lobe prominent and slightly elongated, the surface clothed with long setae bordered by a number of shorter ones; basal lobe triangular, densely tubercular with many setae, those at the margin of the base longer and preceded by a spine. Claspette lightly hirsute except at the apex, the filament short and sickle-shaped with a notch at the base.

Larva.—Upper head hairs 3 to 4, lower 2 to 3. Lateral abdominal hairs usually double. Comb on eighth segment with many scales in a triangular patch. Air tube slender and tapering, four or more times longer than wide with closely set pecten teeth to middle of tube and tuft of 3 to 5 long hairs set close to end of pecten, occasionally one or more teeth may be slightly detached. Anal segment longer than wide; plate extending nearly to ventral line and with a pair of long hairs near posterior angle. Anal gills long and pointed.

Distribution, biology, and importance.—*Aedes fitchii* is most prevalent in mountainous regions, but has also been taken near sea level. The larvae usually appear early in spring in flooded meadows or potholes in semiwooded areas. It is present over most of Oregon, Washington, and Idaho, wherever suitable breeding situations are found. We have found it associated with *increpitus*, *excrucians*, and *pullatus*.

AEDES INCREPITUS Dyar

Aedes increpitus Dyar, Ins. Ins. Mens. 4: 87. 1916.

Female.—Torus without white scales on dorsal half. Mesonotum yellowish white to light brown, with a broad median brown stripe or variable pattern of brown and light scales. Mesepimeral bristles one to five. Wing dark with white scales along the costal area. Legs black, tarsi with basal white bands on all except the last two segments of fore tarsus and first segment of midtarsus, the white bands broader on the hind legs.

The absence of white scales on the dorsal surface of the torus easily distinguishes this species from *fitchii*.

Male genitalia (fig. 37, G).—Side pieces more than three times as long as wide; apical lobe prominent and bluntly pointed with a few small inwardly directed setae; basal lobe a small rugose elevated area with short setae, which extends halfway to the apical lobe. Claspette lightly hirsute except at the apex; the filament angularly expanded to a sharp point near the middle.

Larva.—Antennae well spined all over. Upper head hairs usually 2, occasionally 3; lower 1 or 2. Lateral abdominal hairs 1 or 2 long hairs on each segment. Comb on eighth segment with 25 or more scales in a triangular patch. Air tube about $2\frac{1}{2} \times 1$, pecten not reaching the middle of tube with a tuft of 4 to 6 hairs. Anal segment as long as wide; plate extending only about two-thirds down the sides with lateral edges uneven. Anal gills pointed and only about as long as the segment.

Distribution, biology, and importance.—This is a common species that is generally distributed over the plains areas of Oregon, Washington, and Idaho. The larvae have been taken also in open meadows and small pools in semiwooded country from sea level to an elevation of about 6,000 feet. Near Portland the larvae have been found developing in pools filled by rain in March. The larvae may be associated with *fitchii*, but sometimes they occur alone. This species is one of several found at higher and wooded elevations that contribute to the serious discomfort of man and animals. It is a persistent biter, but prefers shaded situations.

AEDES NIPHADOPSIS Dyar and Knab

Aedes niphadopsis Dyar and Knab, Ins. Ins. Mens. 5: 166. 1918.

Female.—Mesonotum with a median brown stripe and usually with posterior half-lines; the margins, sides, and antescutellar space with white scales. Lower mesepimeral bristles two or three, or rarely none. Abdomen black with basal white bands with or without a median line of white scales. Wings with a mixture of pale and dark scales, the dark predominating. Legs with a mixture of pale and dark scales.

Male genitalia (fig. 39, C).—Side pieces about three times as long as wide, apical lobe small, elongate, narrowly attached, bare or with a few small setae; basal lobe small, elevated into a transverse ridge at the base with a row of 3 or 4 stout hairs preceded by a short spine at the margin. Claspette lightly hirsute on the basal half, the filament expanded in a gradual curve near the middle.

Larva.—Both pairs of head hairs usually single, occasionally double. Comb on eighth segment with 10 to 12 scales in an irregular double row. Air tube nearly 4 x 1; pecten teeth not extending to the middle with the last 2 or 3 teeth detached and followed by a large tuft. Anal segment longer than wide; plate not reaching middle of side. Anal gills short or budlike.

Distribution, biology, and importance.—This species has been found in Klamath County in Oregon and in Fremont, Custer, and Jefferson Counties in Idaho. The adults were present in large numbers in Custer County. Larvae were collected at the edge of drainage ditch in the open country below Klamath Falls in March by Elwood Seaman and by Don Rees in shallow, alkaline pools in valleys of south-central and southeastern parts of Idaho. We have not found it abundant enough to constitute a pest, although it readily bites both man and animals. It has been reported as able to fly several miles.

AEDES IDAHOENSIS (Theobald)

Grabhamia spencerii var. *idahoensis* Theob., Mon. Culic. 3: 250. 1903.

Aedes idahoensis Howard, Dyar, and Knab, Mosq. N. and Cent. Amer. and W. I. 4: 727. 1917.

Female.—Mesonotum with a broad reddish-brown stripe, usually separated by a fine line of grayish scales; faint posterior half-lines present or absent; sides and antescutellar space with grayish-white scales. Lower mesepimeral bristles absent. Abdomen black with broad basal white bands. Wing with costa, first, third, and fifth veins dark-scaled, the other veins with pale scales. Legs mostly pale-scaled; femora, tibiae, and some of apical tarsi partially dark-scaled outwardly.

Male genitalia.—The characters of the male genitalia of this species are the same as those of *sticticus*.

Larva.—Both pairs of head hairs single. Comb on eighth segment with 9 to 20 scales in a very irregular patch. Air tube stout, about 2½ x 1; pecten closely set teeth to middle or slightly beyond, the last two teeth detached and followed by a small tuft. Anal segment longer than wide; plate nearly reaching ventral line. Anal gills pointed and as long or longer than the segment.

Distribution, biology, and importance.—This species is present in a few places in Washington and along the eastern border of

Oregon on the treeless plains or in low mountain areas. It has been found in largest numbers in Bannock and Bear Lake Counties, in southern Idaho, where it is an important daytime pest. The larvae usually develop in irrigated areas, but have been taken in pools of high alkalinity. We have found it associated with *dorsalis* and *increpitus* in spring and early in summer. It is important locally and for a short period late in spring.

AEDES VENTROVITTIS Dyar

Aedes ventrovittis Dyar, Ins. Ins. Mens. 4: 48. 1916.

Female.—Torus with integument of outer side yellow to black. Mesonotum brown, darker centrally, a fringe of yellowish scales around the margin. Lower mesepimeral bristles absent. Abdomen black with basal white bands, which may be narrow or absent medianly. Wing scales dark, with or without a mixture of white scales extending outwardly from the bases of the veins. Legs black with a mixture of pale scales; the tarsi mostly black.

Male genitalia.—The characters of the male genitalia of this species are the same as those of *sticticus*.

Larva.—Both pairs of head hairs single. Comb on eighth segment with 6 to 9 thornlike scales with basal spinules in an irregular row. Air tube tapering, about 2½ x 1; pecten reaching nearly to middle of tube with two detached teeth and with the tuft of 5 to 6 hairs near middle of tube. Anal segment longer than wide, with plate nearly reaching ventral line. Anal gills long and pointed.

Distribution, biology, and importance.—This species has been taken in central Washington and southeastern Idaho. The larvae develop in pools in mountain meadows at high elevations. Little is known about its habits and distribution.

AEDES INTRUDENS Dyar

Aedes intrudens Dyar, Ins. Ins. Mens. 7: 23. 1919.

Female.—Torus with integument of outer side yellow or light brown. Mesonotum uniformly bronzy brown or occasionally with indications of median brown stripes. Lower mesepimeral bristles one to five. Hypostigial spot of scales present or absent. Abdomen black with broad basal white bands; venter completely white-scaled. Wing scales dark, with or without a small patch of pale scales at base of costa. Legs black with a mixture of pale scales; the tarsi mostly black.

Male genitalia (fig. 37, I).—Side pieces about three times as long as wide; apical lobe prominent rounded with numerous rather long setae; basal lobe represented by a large spine at the base of one side and two spines on a raised projection on the other. Claspette with basal half hirsute and forming a sharp projection ending in stout setae at middle. The apical half slender; the filament angularly expanded to a sharp point at the middle.

Larva.—Upper head hairs usually 4, lower 2 or 3. Lateral abdominal hairs double on first segment and single on second to sixth. Comb on eighth segment with 10 to 15 scales in an irregular double row. Air tube 2½ x 1; pecten reaching the middle with 2 to 3 detached teeth followed by large multiple tuft. Anal segment longer than wide; plate extending to near ventral line and ventral margin deeply incised. Anal gills short and bluntly pointed.

Distribution, biology, and importance.—*Aedes intrudens* larvae have been found in small numbers in snow-water pools in low mountainous areas of southeastern Idaho and in northern Oregon. It is typically a forest species and usually survives there as adults from May until mid-August. It is rarely abundant enough to be of much importance. It is a vicious biter day and night.

AEDES HEXODONTUS Dyar

Aedes hexodontus Dyar, Ins. Ins. Mens. 4: 83. 1916.
Aedes cyclocerculus Dyar, Ins. Ins. Mens. 8: 23, 1920.
Aedes leuconotips Dyar, Ins. Ins. Mens. 8: 24. 1920.

Female.—Mesonotum yellowish to light golden brown, with paired dark-brown lines and posterior half-lines. Lower mesepimeral bristles, 2 or 3. Abdomen black with basal segmental white bands. Wings dark-scaled with patch of 2 or 3 to many pale scales at base of costa in about 95 percent of specimens. Legs black with femora partially pale-scaled.

Male genitalia (fig. 38, B).—Side pieces three times as long as broad; apical lobe long and rounded with short curved setae; the basal lobe flatly conical with numerous setae and a long curving spine near the base. Claspette pilose, slightly curved and expanded near the middle; the filament shorter than the stem, slightly expanded at the middle and terminating in a blunt curved point.

Larva.—Antenna sparsely spined. Both pairs of head hairs usually in multiples of 2 or 3. Comb on eighth segment with 5 to 9 scales in a row. Air tube 3 x 1; pecten fine and even and not quite reaching the middle of the tube. Anal segment slightly longer than wide and ringed by the plate. Anal gills pointed and longer than the segment.

Distribution, biology, and importance.—*Aedes hexodontus* is a mountain species usually associated with *communis* and *fitchii.* It is not so widely distributed as these species in the Northwest but in some areas it is very abundant and an important pest. Large numbers of the larvae develop in meadows in the Cascade Mountains in the vicinity of Mount Adams and Rainier National Park in Washington and in the Mount Hood and Diamond Lake areas in Oregon. This species has also been taken in various places in Idaho. In shaded areas it is a vicious biter during the day.

AEDES CATAPHYLLA Dyar

Aedes cataphylla Dyar, Ins. Ins. Mens. 4: 86. 1916.
Aedes pearyi Dyar and Shannon, Wash. Acad. Sci. Jour. 15: 78. 1925.

Female.—Torus with integument of outer side dark brown or black. Mesonotum gray around the sides with golden-brown scales in the middle, which sometimes show faint dark lines. Scutellum with pale-yellowish scales. Lower mesepimeral bristles 2 to 7. Hypostigial spot of scales usually present. Abdomen black with basal segmental white bands. Legs black with a mixture of pale scales; the tarsi mostly black. Wing scales dark with pale scales at base of costa and first vein.

Male genitalia. — Side pieces about three times as long as wide. The filament of the claspette expanded in a gradual curve near the middle. The other characters as in *impiger*.

Larva.—Both pairs of head hairs single. Comb on the eighth segment in two irregular rows.

Air tube about 3 x 1, tapering, with evenly spaced pecten teeth to the hair tuft, and beyond the tuft there are 3 to 5 widely spaced teeth. Anal segment longer than wide; plate small, only reaching about two-thirds of the distance down the sides. Anal gills as long or longer than the segment.

Distribution, biology, and importance.—This species is found only in a few places in mountain areas of Oregon, Washington, and Idaho. The eggs hatch very early when first covered with melting snow. The adults have been taken as early as May and are usually abroad before associated species. It is a vicious biter, and will bite in bright sunshine.

AEDES NEARCTICUS Dyar

Aedes nearcticus Dyar, Canad. Arct. Exp. Rept. 3 (C): 32. 1919.

Female. — Mesonotum bronzy brown with or without a mixture of yellowish-white scales around the sides and two lighter colored patches of scales centrally, the entire surface with many black bristles. Scutellum with pale yellowish scales. Lower mesepimeral bristles 3 to 8. Abdomen black with basal segmental white bands. Wing scales dark with a patch of pale scales on the base of the costa. Legs black with femora and tibiae partially pale-scaled.

Male genitalia (fig. 37, F).—Side pieces about three and one-half times as long as wide; apical lobe rounded, the surface with a few small setae; basal lobe conically sloped to the basal edge, with long setae and a spine at the margin, the rest of the surface bare or with a few small setae. Claspette hirsute on basal half, the filament angularly expanded to its maximum width near the base.

Larva.—Antennae sparsely spined.—Both pairs of head hairs single. Lateral abdominal hairs multiple on first segment and double on second to fifth. Comb on eighth segment 8 to 14 scales in two irregular rows. Air tube about $2\frac{1}{2}$ x 1; pecten on basal third followed by multiple tuft. Anal segment as long as wide. Anal gills stout and several times the length of the segment.

Distribution, biology, and importance.—This species occurs in a few places in the high mountainous areas of Oregon, Washington, and Idaho. The largest numbers have been found in Mount Rainier National Park in Washington and near Diamond Lake in Oregon. The larvae hatch with the first melting snow. The species is too rare to be of much importance.

AEDES STICTICUS (Meigen)
Floodwater Mosquito

Culex sticticus Meigen, Syst. Beschr. Zweifl. Ins. 7: 1. 1838.

Culex hirsuteron Theob. Mon. Culic. 2: 98. 1901.

Aedes aonimus Dyar and Knab Ins. Ins. Mens. 5: 165. 1918.

Aedes lateralis (Meig.). Edwards in Wytsman, Gen. Ins. 194: 144. 1932.

Aedes aldrichii Dyar and Knab, U. S. Natl. Mus. Proc. 25: 57. 1908.

Female.—Mesonotum yellowish white, with two golden-brown stripes and posterior half-lines; the anterior stripes separated by a narrow median line of pale scales, which is sometimes indistinct or absent. Lower mesepimeral bristles absent. Abdomen black with basal white bands. Wing scales dark with or without a patch of pale scales on the base of the costa. Legs black with femora and tibiae partially pale-scaled.

Male genitalia (fig. 38, C).—Side pieces nearly three times as long as wide; the apical lobe large and rounded with short, curved setae; the basal lobe expanded, semidetached apically; the outer surface with short setae, a large spine at the base and an adjoining tuft of long setae. Claspette cylindrical and slightly tapered at the apex with one or two spines at the midpoint of the inner side; the filament short, broad, expanded at the middle, and terminating in a blunt, curved point

Larva.—Upper head hairs 2 or 3, lower 1 or 2. Lateral abdominal hairs variable, usually multiple on first segment and double on second to sixth. Comb on eighth segment with many scales in a triangular patch. Air tube stout, $2\frac{1}{2} \times 1$; closely set, even pecten teeth to near middle of tube, with a multiple tuft set close to pecten. Anal segment broader than long; plate extending nearly to ventral line. Anal gills long and pointed.

Distribution, biology, and importance.—This is one of the most important pest mosquitoes in the Northwestern States. It breeds in large numbers in the brushy bottom lands along the Columbia River. It is also found along some other rivers in northwestern Washington and northern Idaho. The larvae, which are almost invariably associated with those of *vexans,* are found in large numbers for about 100 miles below Bonneville Dam, when the annual spring flood of the Columbia inundates the bottom lands. The adults disperse for a distance of 15 to 20 miles or more and remain a serious pest to man and livestock throughout the summer. The eggs may remain viable for at least 3 or 4 years if not reached by normal floods. This species has been found capable of transmitting western equine and St. Louis encephalitis viruses.

AEDES PULLATUS (Coquillett)

Culex pullatus Coq., Ent. Soc. Wash. Proc. 6: 168. 1904.

Female.—Torus with integument of outer side black to dark brown. Mesonotum with yellowish-brown scales; a narrow bare median line with parallel stripes of brown scales, each stripe bordered by a broader stripe with a few dark scales; with or without narrow, bare, curved posterior half-lines. Lower mesepimeral bristles 1 to 5. Hypostigial spot of many white scales. Abdomen black with basal white bands. Wings dark-scaled with patch of pale scales at base of costa. Legs black with femora and tibiae partially pale-scaled.

Male genitalia (fig. 37, H).—Side pieces about three and one-half times as long as wide; apical lobe prominent and somewhat elongated, by ventral surface covered with numerous setae; basal lobe represented by a large spine at the margin and two adjacent smaller spines. Claspette with basal half large, hirsute, and forming a rounded projection at the middle, the apical half slender; the filament angularly expanded to a rounded point near the middle.

Larva.—Upper head hairs 5 to 7, lower usually 4; hairs short and tufts set close together. Lateral abdominal hairs long, and double or triple on first to fifth segment and single on sixth. Comb on eighth segment with many scales in a triangular patch. Air tube 3×1, pecten teeth closely set, not reaching the middle, closely followed by large 6- to 7-haired tuft. Anal segment longer than wide, not ringed by the plate. Anal gills saclike and two or three times longer than the segment.

Distribution, biology, and importance.—This species has been taken in a number of places in the high forested mountainous areas of the Northwest. The larvae are usually found in melting snow pools, most frequently associated with *communis* but also with *punctor* and *fitchii.* The adults emerge rather late and are severely annoying for only a short time after emergence. They will bite during the daylight hours in shade.

AEDES TRICHURUS (Dyar)

Culex trichurus Dyar, N. Y. Ent. Soc. Jour. 12: 170, 244. 1904.

Female.—Torus with integument of outer side yellow to light brown. Mesonotum with a median brown stripe expanded to width behind the middle; sides and margins with grayish-white scales. Lower mesepimeral bristles 3 to 6. Hypostigial spot of few to many white scales. Abdomen black with basal segmental white bands. Wing scales dark, with patch of 2 or 3 to many pale scales at base of costa. Legs black with femora pale-scaled beneath.

Male genitalia. — Side pieces three times as long as wide; apical lobe prominent and angularly rounded with a few setae; basal lobe small with conical center portion covered with setae and an adjacent elevated portion bearing two long spines. Claspette with long, cylindrical, curved stem slightly expanded before the apex; the filament short and conical, with a series of transverse ridges.

Larva.—Upper head hairs usually double, lower single. Lateral abdominal hairs triple on first segment, double on second and third, and single on fourth to sixth; other hairs few and small. Comb on eighth segment in double row. Air tube stout and about 3 x 1; pecten reaching basal fourth of tube with 4 to 5 widely separated detached teeth, and multiple hair tuft within the pecten, and an additional small tuft on dorsal and lateral surfaces of siphon. Anal segment as long as wide, with plate nearly reaching ventral line. Anal gills ensiform and slightly longer than segment.

Distribution, biology, and importance.—This mosquito occurs in timbered areas at high elevations in Idaho and near Mount Adams in Washington. The larvae have been found associated with those of *fitchii, increpitus, cinereus,* and *communis* in pools formed by melting snow. Although a severe biter, this species does not occur in large enough numbers to be of much importance.

AEDES COMMUNIS (DeGeer)

Culex communis DeG., Mem. des. Ins. 6, pl. 17, figs. 2 and 5. 1776.

Female.—Mesonotum dull-yellow or gray-scaled with a narrow pale median line separating paired dark-brown lines, and with posterior brown half-lines. The coloration is variable and may be brown-scaled centrally with a mixture of pale scales and a border of grayish-yellow scales. Lower mesepimeral bristles 2 to 5. Abdomen dark brown with basal white bands. Wings dark-scaled, with a patch of 2 or 3 to many pale scales at base of costa in about 85 percent of specimens. Legs dark with femora partially pale.

Male genitalia (fig. 39, A).—Side pieces about three times as long as wide; apical lobe large rounded with many long spinelike setae; basal lobe small, quadrilateral in outline, partially detached at base, the surface with some small setae, several larger curved ones and a stout spine on the margin. Claspette lightly hirsute on the basal half, the apical half more slender; the filament angularly expanded to its maximum width near the base.

Larva.—Both pairs of head hairs single. Lateral abdominal hairs double on first to fifth segment and single on the sixth. Comb on eighth segment with many scales in a triangular patch. Air tube stout and about $2\frac{1}{2} \times 1$; pecten evenly spaced to near middle of tube; tuft of 4 to 6 hairs. Anal segment longer than wide; plate extending only about two-thirds the distance down the sides. Anal gills lanceolate and considerably longer than the segment.

Distribution, biology, and importance.—This is one of the most widely distributed species in high mountain areas of the Northwest. In many localities it is present in large numbers and is a serious pest. It breeds in flooded mountain meadows and woodland pools left by melting snow, and around the margins of mountain lakes. The larvae may occur along or associated with *pullatus, cataphylla, intrudens, fitchii,* and *hexodontus*. In Oregon it is numerous throughout the Cascade and Blue Mountains. It is abundant in the Cascade and other mountain ranges in Washington and northern Idaho, and is present in smaller numbers in central and southern Idaho. The adults are sometimes seen late in May and may occur until mid-August. They are vicious biters and, although they will attack during the day, are generally more active at dusk.

AEDES PIONIPS Dyar

Aedes pionips Dyar, Ins. Ins. Mens. 7: 19. 1919.

Female.—Tori with white scales. Mesonotum with dull-yellow or white scales, two broad, well-defined, dark-brown stripes and posterior half-lines, the median stripes separated by a line of pale scales. Lower mesepimeral bristles 1 to 4, or rarely none. Abdomen with or without narrow basal white bands. Wing scales dark with small patch of pale scales at base of costa in about 85 percent of specimens. Legs black with femora partially pale-scaled.

Male genitalia.—The side pieces are slightly longer than those of *Aedes communis*. There are no other taxonomic differences in the genitalia of these two species.

Larva.—Antennae long and well spined. Upper head hairs usually 5, lower 4. Comb on eighth segment arranged in a large triangular patch. Air tube about $2\frac{1}{2} \times 1$; pecten not reaching the middle and followed by large multiple tuft. Anal segment about as long as wide, with the plate reaching only about half the distance down the sides, and with notched lateral edges. Anal gills long and pointed.

Distribution, biology, and importance.—This is a rare species in the Northwestern States. The larvae have been found only in small pools in high mountain meadows of south-central Idaho at an elevation of over 7,000 feet. Very little is known about it, and because of its rarity it is of no economic importance.

AEDES IMPIGER (Walker)

Culex impiger Wlkr., Brit. Mus. List Dept. 1: 6. 1848.

Female.—Tori with integument varying from black to yellow. Mesonotum with a median oblong area of brown scales, usually in the form of a broad stripe or paired stripes; margins grayish white. Lower mesepimeral bristles 1 to 3, or rarely none. Wing scales dark with patch of 2 or 3 to many pale scales at base of costa. Legs black with femora pale-scaled beneath.

Male genitalia.—Side pieces about four times as long as wide, apical lobe small elongated and narrowly attached with a few short spines; basal lobe small, elevated into a transverse ridge at the base with a row of long setae and a slender spine at the margin; claspette lightly hirsute except at the apex, the filament angularly expanded to a sharp point near the base.

Larva.—Antennae short and spined. Upper and lower hairs single. Lateral abdominal hairs double on first to fourth segments and single on fifth and sixth. Comb on eighth segment with 15 to 25 scales. Air tube about 2½ x 1; closely set pecten teeth not reaching the middle, followed by tuft of 3 or 4 hairs. Anal segment longer than wide; plate extending about halfway down the sides and covered with minute spines. Anal gills pointed and only about as long as the segment.

Distribution, biology, and importance.—This species occurs in small numbers in Washington and Idaho. The larvae are usually associated with other *Aedes* larvae in pools in semiwooded areas at the higher elevations. It is too rare to be of any importance.

AEDES ABORIGINIS Dyar
Northwest Coast Mosquito

Aedes aboriginis Dyar, Ins. Ins. Mens. 5: 99. 1917.

Female.—Mesonotum yellowish to light golden brown, with paired dark brown stripes and posterior half-lines. Lower mesepimeral bristles 1 or 2. Abdomen black with basal white bands widening at the sides. Wings dark-scaled in about 95 percent of specimens. Legs black.

Male genitalia (fig. 37, D).—Side pieces three times as long as broad; apical lobe long and rounded with short curved setae; the basal lobe flatly conical with numerous setae and a long curving spine near the base. Claspette pilose, slightly curved, and expanded near the middle; the filament shorter than the stem, slightly expanded at the middle and terminating in a blunt curved point.

Larva.—Antennae sparsely spined. Head hairs, upper usually 3 to 4 and lower 2 to 4. Lateral abdominal hairs 1 to 2 long hairs. Comb on eighth segment with about 30 scales in a patch. Air tube around 3 x 1; pecten fine and even and not reaching the middle, the tuft consists of 4 to 6 large hairs. Anal segment about as long as wide; anal plate extending to near ventral line; anal gills pointed and longer than the segment.

Distribution, biology, and importance.—Large numbers of this species are found in the dense timbered coastal areas of Oregon and Washington, where the winter precipitation is very high. It is also common at moderate elevations in the Cascade Mountains and in other mountain areas in Washington and northern Idaho. The larvae are found associated with *communis, cinereus,* and *fitchii* in small temporary rain pools. It is of economic importance only in a few restricted situations in the Olympic Peninsula of Washington.

AEDES CINEREUS (Meigen)

Aedes cinereus Meig. Syst. Beschr. Eur. Zweif. Ins. 1: 13. 1818.

Female.—Mesonotum clothed with reddish-brown scales. Lower mesepimeral bristles absent. Abdomen black without white bands or with narrow partial or complete ones; the lateral spots usually joined to form a line. Wing scales dark. Legs dark brown. Coxa of front leg with white scales and a central patch of brown scales on the anterior surface.

Male genitalia (fig. 38, E).—Side piece twice as long as wide, broad, and sharply tapered to the densely spined apex. Clasper subapically inserted, with forked arms of unequal length. Claspette two-branched with 3 spines at apex of each branch.

Larva.—Both pairs of head hairs in tufts of 5 or more, the tufts set close together. Lateral abdominal hairs double on first and second segments, single and long on the third to sixth. Comb on eighth segment in a double row. Air tube slender, about 4 x 1; pecten extending past middle of tube with about 3 detached teeth; tuft small. Anal segment longer than wide, gills very long and lanceolate.

Distribution, biology, and importance.—This mosquito is found throughout the partially wooded areas of the Northwestern States. It breeds in shaded pools, and the larvae are usually found associated with other species of *Aedes* in March and early in April; it appears a little later than its associates. In some mountain areas it is the predominating species and is a serious pest; it is found in smaller numbers at lower elevations. The females attack both during the day and at dusk, but they stay close to the ground in the grass or underbrush. The adults are not found very far from their breeding places. Apparently their flight range is very limited, since Freeborn (30) states that they prefer to walk rather than fly, and when flying remain close to the ground. This species is a severe biter but important only in local areas.

AEDES VEXANS (Meigen)

Culvex vexans Meig. Syst. Beschr. Eur. Zweif. Ins. 6: 241. 1830.

Female.—Occiput with patch of flat black scales bordering top edge of flat white lateral patch. Mesonotum clothed with bronzy-brown scales, paler at the base of the wings and around antescutellar space. Lower mesepimeral bristles absent. Abdomen black with centrally indented basal white bands. Wing scales brown. Legs black; all the segments of the hind tarsus, the first four segments of the mid-tarsus, and the first three segments of the fore tarsus narrowly white-banded.

Male genitalia (fig. 38, F).—Side pieces twice as long as wide, clasper long, broad, and divided near the apex, the short arm with a stout spine. Claspette short and capitate with dense crown of spines. Filament absent.

Larva.—Upper head hair usually 2 or 3 and lower double. Lateral abdominal hairs 2 to 3 on first to third segment; 2 on fourth and fifth and single on the sixth. Comb on eighth segment with 10 to 25 or more scales in an irregular double row. Air tube 3 x 1; pecten reaching past the middle with 1 to 3 detached teeth and a small multiple-haired tuft near end of pecten. Anal segment longer than wide. Anal gills pointed and longer than segment.

Distribution, biology, and importance.—This species is found over the greater portion of the Northwestern States. It is one of the most important pest species in both irrigated and flood-water areas, and occurs near sea level, as well as in mountain meadows. It is present in overflow areas along many rivers, but is most abundant on the bottom lands along the Columbia River and its tributaries for about 100 miles below Bonneville Dam. In this region the larvae are found associated with those of *sticticus* in the partially open, brushy, or wooded areas that are flooded by the annual spring rise of these rivers. The adults sometimes disperse for distances of 15 to 20 miles or more from their breeding places and are a serious pest to man and livestock for 3 to 4 months during the summer. Along the Columbia River several hatchings may occur, depending on the number of floods, since all eggs do not necessarily hatch with the first flooding. More than one generation may occur in the irrigated sections and there the larvae are associated with *nigromaculis*, *dorsalis*, and *idahoensis*. In mountain areas they are usually found with *increpitus* and *cinereus*. The females enter houses and will feed there during the hours of darkness. They also bite at mid-day in shaded areas. This species has been found naturally infected with western equine encephalomyelitis and has been experimentally infected with St. Louis encephalitis virus.

AEDES VARIPALPUS (Coquillett)

Western Tree-hole Mosquito

Culex varipalpus Coq., Canad. Ent. 34: 292. 1902.

Female.—Palpus black-scaled with the tip broadly white-scaled and a few white scales at apex of second segment. Mesonotum brown with a median anterior patch, and narrow posterior curved lines of yellow scales; the margins with a mixture of pale scales and scutellum with broad white scales. Abdomen black with median triangular dorsal and lateral patches of white scales. Wing scales dark with a patch of white scales at the base of the costa. Legs black, with white bands involving both ends of all but the last two joints of the fore and mid tarsi, which are black, and the last joint of the hind tarsus, which is white.

Male genitalia (fig. 38, D).—Side pieces three times as long as wide; the apical lobe absent; the basal lobe narrow with long spines basally and short setae extending to apical fourth of side piece. Claspette with cylindrical stem, the filament narrow, ligulate and as long as the stem.

Larva.—Antennae slender without spines and with a single hair on the middle. Both pairs of head hairs small and either single or double. Comb on eighth segment with about 12 scales in an irregular double row. Air tube about 3 x 1; pecten evenly spaced on basal third and with tuft near the middle. Anal segment about as long as wide. Anal gills enlarged, spatulate, and about four times as long as segment.

Distribution, biology, and importance.—This small mosquito breeds in water-filled holes in practically any kind of tree. Reeves (*114*) reports finding it also in rock pools and wooden receptacles under trees. The larvae may be found in midwinter in this region if temperatures below freezing do not prevail for long periods. In summer the aquatic stage is completed in about 3 weeks. The species occurs in the western half of Oregon and Washington, but is seldom very abundant. The largest numbers are found in the foothills of the Coast Range and the Olympic Mountains in Washington. It is a vicious biter but has a restricted flight range. It has been found an experimental vector of western equine encephalomyelitis.

Genus MANSONIA Blanchard

MANSONIA PERTURBANS (Walker)

Culex perturbans Wlkr., Ins. Saund., 428. 1856.

Female.—Mesonotum with narrow, curved, pale-yellow scales, with or without two faint silvery longitudinal lines. Abdomen black with narrow basal segmental white band, sometimes lacking medianly or consisting of scattered black and white scales on the last few segments. Wing scales broad, black and white intermixed. Legs black with a mixture of white scales; the hind tibiae with a white ring on the outer third; the first joints of all tarsi with a narrow basal white ring and a broad median white ring; all other tarsal joints with the basal half white-scaled.

Larva.—Antennae long and slender with large tuft beyond the middle and short pair of hairs not far beyond the tuft. Dorsal head hairs in multiple groups. Lateral comb of the eighth segment of 10 to 12 spines in a single irregular row. Air tube short, broad at the base. Attenuated apically and fitted for piercing, a pair of hair tufts near the middle. Anal segment much longer than wide, ringed by the plate, the dorsal tufts of two unequal groups of hairs on each side. Anal gills slender and shorter than segment.

Distribution, biology, and importance.—Many adults of this species are present near Scappoose, Oreg., in some years. Larvae probably occur in cattail swamps in the area but none have been taken. They are difficult to find, because, unlike other mosquito larvae, they attach to the succulent roots of aquatic plants by their siphons and come to the water surface only for emergence as adults. The winter is passed in the larval stage. The pupae also attach to roots. The adults emerge for several weeks in the summer and are extremely vicious biters. Adults have also been taken in small numbers in Washington and Idaho. Fortunately, they are so rare that they are of little importance. Howitt *et al.* (*69*) has shown this species may transmit eastern equine encephalomyelitis in nature.

Genus CULEX Linnaeus

KEY TO SPECIES

Adults

1.	Tarsi and proboscis ringed with white	2
	Tarsi and proboscis not ringed with white	3
2.	Femora and tibia with a line of white scales on the outer surfaces; the inner surfaces of the tori and the ventral surface of the first segment of the flagellum with white scales	*tarsalis*
	Femora and tibia without a line of white scales on the outer surfaces; the inner surfaces of the tori and the first segment of the flagellum without white scales	*stigmatosoma*
3.	Abdominal segments with dorsal, basal white bands	*pipiens*
	Abdominal segments with dorsal, apical white bands	*territans*

Male Genitalia

1.	Mesosome with the halves connected by a narrow sclerotized band before the apex	*territans*
	Mesosome without connecting band before the apex	2
2.	Apical lobe with eight or more appendages	*pipiens*
	Apical lobe with six or less appendages	3
3.	Tenth sternite with spines forming a flattened outline at the apex; the outer spines bluntly rounded	*tarsalis*
	Tenth sternite with spines forming a circular outline at the apex; the spines all pointed	*stigmatosoma*

Larvae

1. Both pairs of head hairs usually single and long, occasionally double ... *territans*
   Both pairs of head hairs multiple ... 2
2. Air tube with four pairs of tufts, the next to last out of line; lateral abdominal hairs multiple on first and second segments, double on third and sixth ... *pipiens*
   Air tube with four to five pairs of tufts all in line or nearly so; lateral abdominal hairs triple on third to sixth segments ... 3
3. Subapical tuft on air tube sometimes smaller and slightly out of line; plate on anal segment indented with row of short bristles near apex ... *stigmatosoma*
   Tufts on air tube uniform and all in line; plate on anal segment with smooth edges and no bristles ... *tarsalis*

CULEX TERRITANS (Walker)

Culex territans Wlkr, 1856. Insects Saundersiana, Dipt., 1: 428.
Culex apicalis Adams, of Dyar and other authors, not of Adams.

Female. — Mesonotum brown-scaled with median indistinct nearly bare lines and usually with two median spots of yellowish scales. Abdomen black-scaled with apical segmental white bands. Wing scales all black. Legs black, the undersurface partially white-scaled.

Male genitalia (fig. 36, D).—Side piece more than twice as long as wide; subapical lobe with two large rods, a spine and five hooked filaments. The first three partially serrated. Tenth sternite prominent, the apex broad, extending beyond the mesosome and terminating in a row of short setae. Mesosome halves with relatively even, oblong outlines terminating apically in a rounded, serrated margin, the halves joined by a sclerotized band near the apex.

Larva.—Head hairs single or double. Antennae large, cylindrical, and spined. Lateral abdominal hairs multiple on first and second segments and double on third to sixth; secondary hairs numerous and well-developed. Comb on eighth segment with numerous scales in a triangular patch. Anal segment twice as long as wide and anal gills about as long as the segment. Air tube long and tapering, about 7 x 1; pecten of 12 to 14 teeth on basal third of tube with four pairs of prominent tufts beyond pecten, and also sometimes a small fifth pair near the apex.

Bohart (*10*) found that *C. apicalis* consisted of two species. He used this name for the species found in California and Arizona, but applied the name *"territans"* to the more widespread species which occurs in other parts of North America.

Distribution, biology, and importance.—This species is well distributed in the Northwestern States. The larvae have been collected in semishaded and in open grassy pools. They are never found in large numbers. The females feed on cold-blooded animals, such as frogs, and are not known to attack man or other warm-blooded animals.

CULEX PIPIENS (Linneaus)

Northern House Mosquito

Culex pipiens L., Syst. Nat., ed. 10: 602. 1758.

Female.—Mesonotum brown-scaled. Abdomen black with basal segmental white bands, which are widest at the middle and at the sides. Wing scales all brown. Legs brown-scaled.

Male genitalia (fig. 36, C).—

Side pieces more than twice as long as wide, subapical lobe with 8 appendages, beginning at the apical end; a seta, a leaf, 3 setae, and 3 rods. Tenth sternite prominent and extending beyond the mesosome, and the apex semicircular and densely crowned with stout spines. Mesosome halves each with ends of 3 processes projecting outwardly past the outer edges of the tenth sternite.

Larva.—Both pairs of head hairs multiple. Antennae large, spinose, cylindrical, and constricted beyond the tuft. Lateral abdominal hairs multiple on first and second segments and double on third to sixth; subdorsal hairs of segments 3 and 4, single or double. Comb on eighth segment with numerous scales in a triangular patch. Anal segment longer than wide and gills slightly longer than the segment. Air tube gradually tapering, about 5 x 1; pecten about 12 teeth on basal fourth followed by 4 pairs of hair tufts, the subapical pair more dorsal and out of line than the others.

Distribution, biology, and importance.—This species is occasionally present in large numbers in some communities in the western parts of Oregon and Washington. It seldom occurs in the eastern half of these States. The larvae breed in temporary and permanent pools and in artificial containers. Because of its habit of developing in any polluted place provided by man, it is often abundant and annoying around homes and industrial plants. It enters houses freely and overwinters in basements, root cellars, and other shelters. The flight range is short and, if breeding places are not great in number and widely scattered, the area affected is small. Western equine encephalomyelitis and St. Louis encephalitis viruses have been recovered from this species in nature and experimentally it has been shown to be a vector of Japanese B encephalitis virus.

CULEX TARSALIS Coquillett

Culex tarsalis Coq., Canad. Ent. 28: 43. 1896.

Female.—Proboscis ringed with white. Tori with inner surfaces, and basal segment of flagellum with ventral surface bearing many white scales. Mesonotum dark brown with white scales around the margins and 2 narrow white lines extending posteriorly from median white spots. Abdomen black with basal segmental white bands; venter with pale scales, each segment marked with a dark-scaled V. the apex anteriorly directed. Wing scales dark with some white scales on the costal veins. Legs black, the femora and tibia with a line of white scales on the sides, the tarsi with a ring of white scales at both ends of all joints except the first 1 or 2 on the front and middle legs.

Male genitalia (fig. 36, B).—Side pieces more than twice as long as wide; subapical lobe usually with five appendages, beginning at the apical end; a seta, a narrow leaf, a seta, and two rods. Tenth sternite prominent, well chitinized, and extending beyond the mesosome, the broad apex crowned with short pointed spines medianly and short, broad, blunt ones outwardly. Mesosome halves each consisting of inner sword-like blade and an outer 4-pronged process.

Larva.—Both pair of head hairs multiple. Antennae long and curved, basal two-thirds spinose and enlarged. Lateral abdominal hairs triple on third to sixth segments. Comb on eighth segment with numerous scales in a triangular patch. Anal segment slightly longer than wide; gills as long as segment and bluntly pointed. Anal plate without bristles. Air tube slender and about 5 x 1; pecten on basal third followed by 5 pairs of tufts, none displaced or out of line.

Distribution, biology, and importance.—This (fig. 2) is one of the most abundant and widely distributed mosquitoes in the Northwestern States. It has been collected in every county in Oregon and from all but a few counties in Washington and Idaho. It occurs in largest numbers in poorly drained irrigated areas where water accumulates. It is readily found around Klamath Lake, along the John Day River, and elsewhere in eastern Oregon. In Washington it is common in Yakima and Okanogan Valleys, and in western Idaho it is very numerous in the lower Boise and Payette River Valleys. It is also abundant around American and Bear Lakes, in Idaho. The larvae are associated with anophelines, *Aedes dorsalis*, and *Culiseta inornata*. The females pass the winter in hibernation. *Culex tarsalis* has been shown to be infected in nature with both St. Louis encephalitis and western equine encephalomyelitis in several areas and is capable of transmitting these diseases to chickens. It has been experimentally infected with Japanese B and California encephalitis viruses.

CULEX STIGMATOSOMA Dyar

Culex stigmatosoma Dyar, U. S. Natl. Mus. Proc. 32: 123. 1907.

Female.—Proboscis ringed with white. Tori without scales and basal segment of flagellum brown-scaled. Mesonotum with bronzy-brown scales intermingled with paler ones and forming no definite pattern. Abdomen black with basal segmental white bands; venter pale-scaled, each segment marked with a median oval dark-scaled spot. Wing scales all dark. Legs black, the tarsi with a ring of white scales on both ends of all joints except the first one or two of the front and middle legs.

Male genitalia (fig. 36, A).—Side pieces more than twice as wide as long; subapical lobe usually with 6 appendages, beginning at the apical end—a seta, a leaf, a seta, and 3 rods. Tenth sternite prominent, well sclerotized, and extending beyond the mesosome, the apex semicircular and densely crowned with slender spines, with a few slightly heavier ones on the outer margin. Mesosome similar to mesosome of *tarsalis*.

Larva.—Both pairs of head hairs multiple. Lateral abdominal hairs triple third to sixth segments and subdorsal hairs, 3-branched, on segments 3 and 4. Comb on eighth segment with many scales in a patch. Anal segment about as long as wide; anal plate indented and with row of short bristles near apex; anal gills broad and as long as segment. Air tube about four to five times as long as wide; pecten on basal third followed by five pairs of hair tufts, but apical one usually very small; subapical one sometimes out of line.

Distribution, biology, and importance.—In western Oregon and Washington the larvae of this species are usually associated with *tarsalis* or other species of *Culex* and *Culiseta*. It has not been taken in the eastern half of these States or in Idaho. Western equine encephalomyelitis has been isolated in nature from this species, but it is probably of little importance as a vector because of its limited numbers and distribution.

Genus CULISETA Felt

KEY TO SPECIES

Adults

1. Tarsi with white bands on some of the segments 2
   Tarsi without white bands 4
2. Femora with subapical white rings ....*maccrackenae*
   Femora without subapical white rings 3
3. Wing scales black and clustered into spots .... *incidens*
   Wing scales brown and evenly distributed .... *morsitans*
4. Wing scales brown with an admixture of white scales on the anterior veins .... *inornata*
   Wing scales all brown .... *impatiens*

Male Genitalia

1. Apical lobe absent 2
   Apical lobe present 3
2. Lobes of the ninth tergite with short broad spines .... *inornata*
   Lobes of the ninth tergite with rather long setae .... *morsitans*
3. Eighth segment with row of 20 to 40 short spines on basal margin; basal lobe large with single spinelike sets .... *impatiens*
   Eighth segment with less than 12 spines on the basal margin; the basal lobe with 2 or 3 spines 4
4. Eighth segment without spines or with a single short spine at the center of the basal margin: (the basal lobe with 3 stout spines) *maccrackenae*
   Eighth segment with 5 to 10 spines at the center of the basal margin *incidens*

Larvae

1. Pecten on air tube not produced into long hairs on outer half .... *morsitans*
   Pecten teeth normal near base and becoming long hairs near apex of tube 2
2. Upper and lower head hairs multiple and similar; a tuft of small hairs on posterior margin of anal plate .... *impatiens*
   Upper and lower head hairs multiple, the lower hairs longer...... 3
3. Basal pecten on air tube with 3 or more outstanding denticles; a tuft of 1 to 3 long stout hairs on posterior margin of anal plate.. *inornata*
   Basal pecten on air tube with minute denticles; a tuft of small hairs on posterior margin of anal plate 4
4. Anterior tufts of ventral brush puncturing anal plate .... *incidens*
   Anterior tufts of ventral brush in a cleft in anal plate, a tuft of small bristles near its apex ....*maccrackenae*

CULISETA MACCRACKENAE Dyar and Knab

Culiseta maccrackenae, Dyar and Knab. Biol. Soc. Wash. Proc. 19: 133. 1906.

Female.—Mesonotum dark brown with a light-brown median stripe and narrow white posterior half-lines; the sides, anterior margin, and margins of antescutellar space with a mixture of white scales. Abdomen black with basal segmental white bands and a few scattered white scales. Wing scales black with a few pale scales on the costal veins, the dark scales forming spots at the base of the second, the forks of its second and fourth, the upper fork of the fifth and on the cross veins. Legs black with portion of inner side white-scaled, femora with subapical white ring followed by a black ring, apical segments of tarsi without rings and succeeding tarsi with gradually broadening white rings.

Male genitalia.—Side piece about three times as long as wide; apical lobe a small elevated area with a number of long setae; basal lobe small and conical with many small setae, the apex with two or three stout spines.

Lobes of the ninth tergite not separated but indicated by two large groups of small spines. Eighth segment without spines or with one spine at center of basal margin.

Larva.—Both pairs of head hairs multiple, the lower with about three long hairs, the upper more numerous and shorter. Air tube stout, about 2 x 1; pecten with a few basal teeth followed by long hairs that extend nearly to apex of tube; a paired tuft near base of tube between rows of pecten. Anal segment ringed by the plate with 2 anterior tufts of ventral brush arising from a cleft in the plate and a small patch of short bristles near apex of the plate. Anal gills slightly longer than segment.

Distribution, biology, and importance.—This species is rare in the Northwest; it has been taken only in a few places in southwestern Oregon. The larvae were found associated with larvae of *incidens* and *territans* in pools overgrown with vegetation.

CULISETA INCIDENS (Thompson)

Culiseta incidens Thompson, Kongl. Sven. Eng. Resa. 6, Dipt.: 433. 1868.

Female.—Mesonotum with dark-brown scales and a mixture of yellowish scales some of which form partial longitudinal lines or spots. Abdomen black with basal segmental white bands. Wing scales dark, aggregated into patches on the fork and base of the second vein, the fork of the second and fourth vein, the upper fork of the fifth and the middle of the sixth veins. Legs dark brown with narrow faint white rings on the bases of some of the tarsal joints, the femora and tibia with narrow white rings at their apices.

Male genitalia (fig. 39, F).—Side piece more than twice as long as wide, apical lobe a small elevated area with a number of small setae and a long spine; basal lobe small and conical with small setae, the apex with 2 stout spines. Lobes of ninth tergite slightly separated, and each bearing 5 to 8 rather long setae. Eighth segment with 5 to 8 spines on basal margin.

Larva.—Both pairs of head hairs multiple, lower tufts longer than the upper. Lateral abdominal hairs multiple on first and second segments and double on third to sixth. Air tube stout about 2 x 1; pecten with a few basal teeth that have 1 or 2 minute denticles, teeth followed by long hairs to apical third of tube; and a multiple tuft near base between rows of pecten. Anal segment ringed by the plate with several tufts of ventral brush puncturing the plate and a small 1- to 3-haired tuft on lateral posterior margin. Anal gills slightly longer than segment.

Distribution, biology, and importance.—This species is widely distributed at lower elevations in the Northwestern States. The largest numbers occur in Oregon and Washington west of the Cascade Mountains, but it is common also in southern Idaho. The larvae breed in both permanent and semipermanent pools and in artificial containers. They are associated with *inornata* and *tarsalis*. Only the females hibernate. They occasionally attack man, but they are of little importance as a pest. The species has been reported as favoring animals for blood meals, although it is seldom abundant enough to be a pest of livestock. It has been infected experimentally with western equine encephalomyelitis and St. Louis and Japanese B encephalitis viruses.

CULISETA INORNATA (Williston)

Culex inornatus Williston, U. S. Dept. Agr., Div. Ornith. and Mam., N. Amer. Fauna 7: 253. 1893.

Female.—Mesonotum with mixture of brown and yellowish scales, usually with 2 fine, pale, median posterior half lines and pale obscure longitudinal stripes. Abdomen black with broad basal segmental bands widening at the sides, the last segment entirely pale scaled. Wing scales dark brown with mixture of pale scales on the anterior veins. Legs with a mixture of brown and pale scales.

Male genitalia (fig. 39, G).—Side pieces stout conical, less than twice as long as wide; apical lobe absent or faintly indicated; basal lobe conical and prominent, with 2 or 3 spines on the apex and small setae on the sides. Lobes of the ninth tergite broad, rounded projections with 10 to 14 short, thick spines. Eighth segment without row of spines on basal margin.

Larva.—Both pairs of head hairs multiple, the lower with 3 or 4 long hairs, and upper multiple and shorter. Lateral abdominal hairs multiple on first and second segments and double on third to sixth. Air tube stout, 3 x 1; pecten of 10 to 12 stout teeth followed by long hairs that extend nearly to apex of tube, the teeth with 3 to 4 outstanding denticles; paired tuft large and arising from base of tube between the rows of pecten. Anal segment ringed by the plate with 2 to 3 anterior tufts of ventral brush piercing the plate and a tuft of 1 to 2 long hairs on its lateral posterior margin. Anal gills longer than segment with tips rounded.

Distribution, biology, and importance.—This species is widely distributed in the Northwestern States. It occurs in largest numbers in poorly drained irrigated areas. Under such conditions the larvae are usually found with those of *freeborni* and *tarsalis*. It is also found in shaded pools in forests at elevations up to 6,000 feet. It seldom bites man, but can become a pest of livestock because of its long breeding season and wide distribution in irrigated areas. The females hibernate, and Rees (*111*) believes that some larvae may overwinter, since they are very resistant to low temperatures. Western equine encephalomyelitis has been isolated from this species in nature. Experimentally, it has been shown to transmit St. Louis and Japanese B encephalitis viruses.

CULISETA MORSITANS (Theobald)

Culex morsitans Theob., Mon. Culic. 2: 8. 1901.

Female.—Mesonotum brown with a mixture of yellowish scales around the margins, a pair of faint nearly bare median stripes, and posterior yellowish white half-lines. Abdomen brown-scaled with scattered yellowish-white scales, most heavily concentrated along the apices and bases of segments, or these may occasionally form basal pale bands only. Wing scales dark with pale scales at the base of the costa. Legs dark with faint white rings at both ends of the tarsal joints.

Male genitalia (fig. 39, H).—Side pieces conical, more than twice as long as wide; apical lobe absent; basal lobe prominent and conical, with 3 to 5 spines on the apex and small setae on the sides. Lobes of the ninth tergite with broad projections each with 6 to 12 slender setae. Eighth segment with a group of small spines centrally on basal margin.

Larva.—Upper head hairs multiple, lower double. Lateral abdominal hairs multiple on first and second segments, single and long on third to sixth. Air tube about 6 x 1; pecten 6 to 9 teeth on basal fourth; a small paired tuft at base between the rows of pecten. Anal segment longer than wide and ringed by plate. Anal gills slender and longer than the segment.

Distribution, biology, and importance.—This rare species has been found in small numbers in Kittitas and Yakima Counties in Washington and in Columbia, Clatsop, and Klamath Counties in Oregon. It has been reported from Franklin County, Idaho. The larvae have been collected from unshaded pools grown up with rank grass and fed by fresh water. This mosquito is not known to bite man, and very little is known about it.

CULISETA IMPATIENS (Walker)

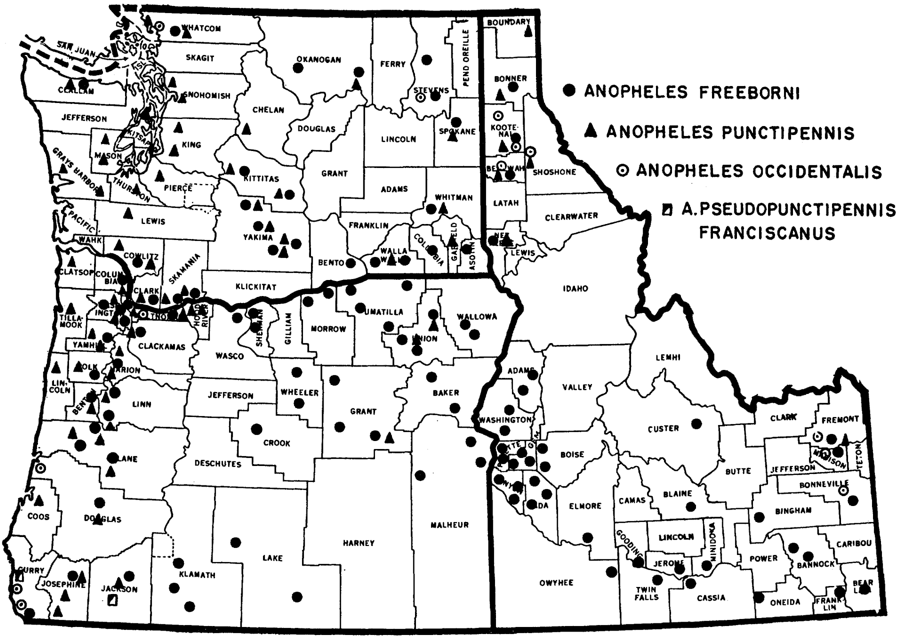
Culex impatiens Wlkr. Brit. Mus. Dipt. List 1: 5. 1848.

Female.—Mesonotum with brown and yellowish scales, two fine pale lines extending posteriorly from median pale patches and a variable pattern of other pale scales. Abdomen black with basal segmental white bands. Wing scales brown and aggregated to form faint spots at the forks of second and fourth veins, and the bases of the second and third veins. Legs black, the femora white tipped.

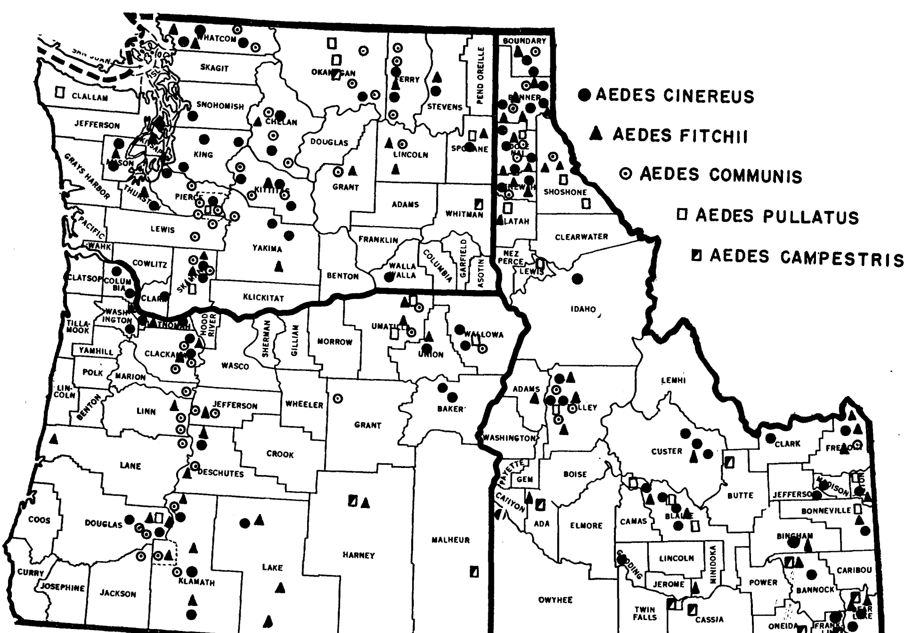
Male genitalia (fig. 39, E).—Side pieces stout conical, about twice as long as wide; apical lobe a small slightly elevated chitinized area with long setae; basal lobe large and conical in outline, the apex rounded with 1 large spine-like seta and several smaller ones. Lobes of the ninth tergite only slightly separated and each bearing about 10 long setae. Eighth segment with a row of 20 to 40 short stout spines on basal margin.

Larva.—Both pairs of head hairs multiple and long. Lateral abdominal hairs multiple on first to fifth segment and double on the sixth. Air tube stout, 2 x 1; pecten of 8 to 9 teeth on basal fourth, followed by long hairs that nearly reach apex of tube; paired tufts large and arising close to base between rows of pecten. Anal segment wider than long, ringed by the plate with 2 to 3 of the anterior tufts of ventral brush puncturing the plate, and with a tuft of small hairs near posterior margin. Anal gills bluntly pointed and longer than the segment.

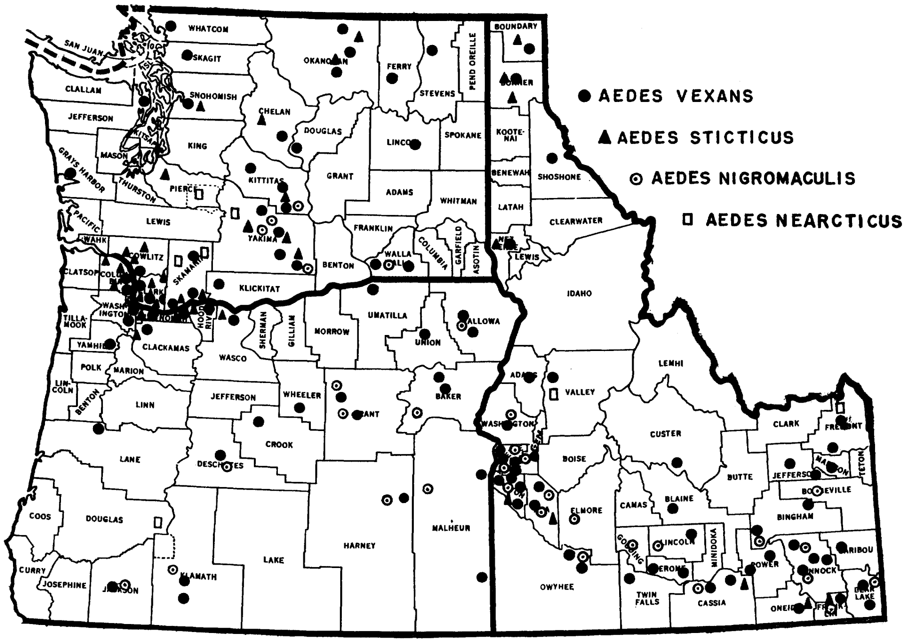
Distribution, biology, and importance.—This species has been found in small numbers in a few timbered sections of Oregon and Washington and in Fremont County, Idaho. The larvae usually develop in shaded spring- or snow-fed pools. The overwintered females can usualy be found in the woods very early in spring on warm days. They are said to prefer animals for food, but will bite man at times.



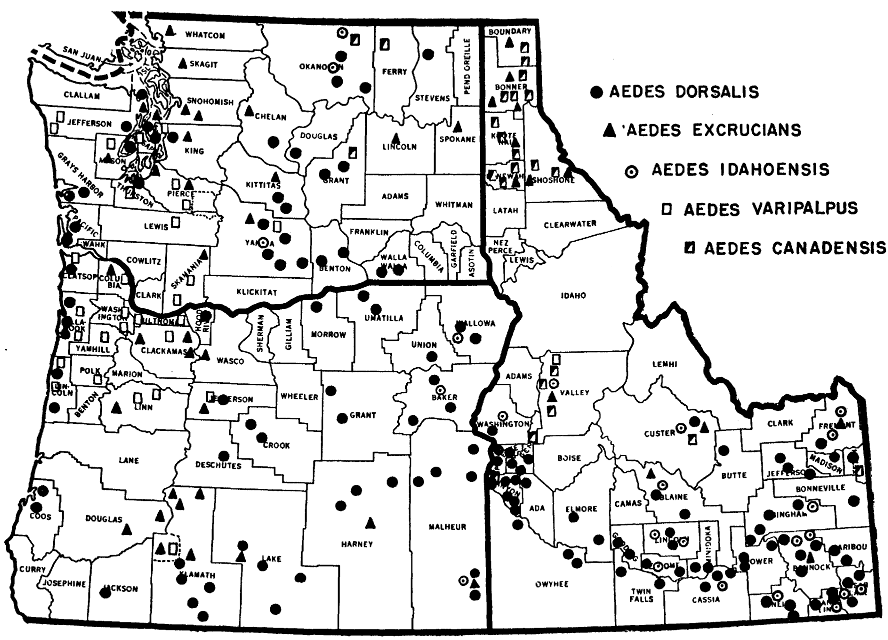
MAP 1.—Distribution of *Anopheles freeborni, punctipennis, occidentalis,* and *pseudopunctipennis franciscanus* in the Northwest.



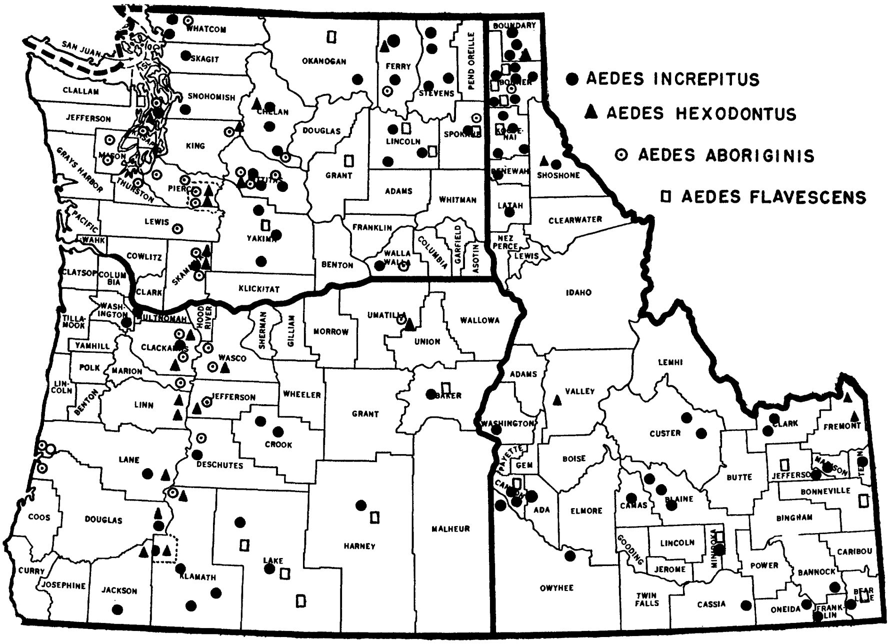
MAP 2.—Distribution of *Aedes cinereus, fitchii, communis, pullatus,* and *campestris* in the Northwest.



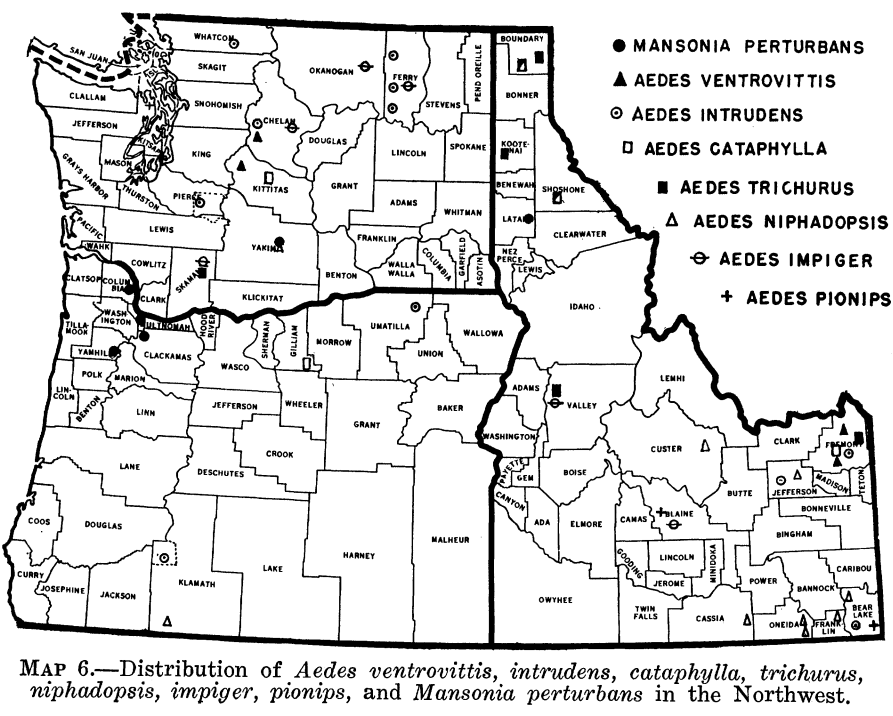
MAP 3.—Distribution of *Aedes vexans, sticticus, nigromaculis,* and *nearcticus* in the Northwest.



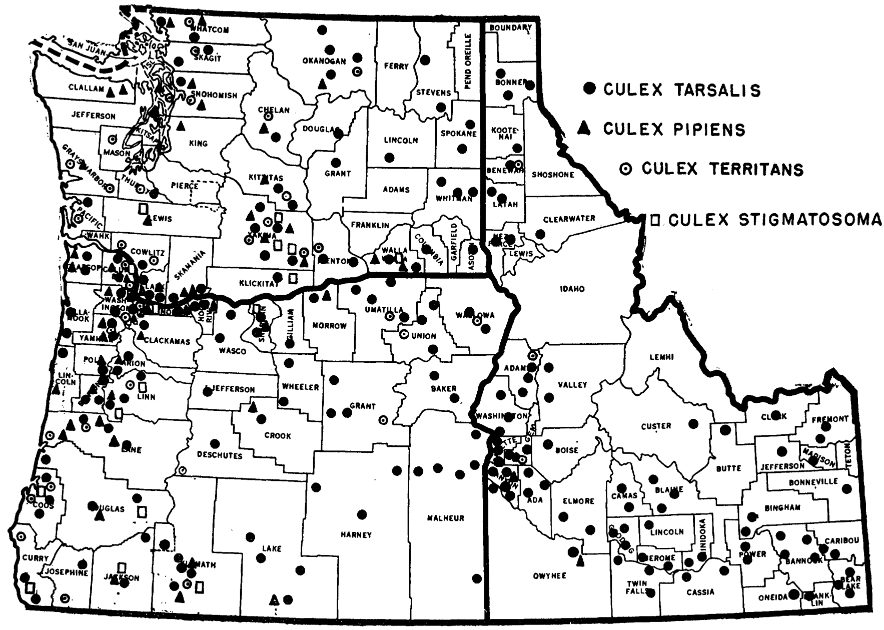
MAP 4.—Distribution of *Aedes dorsalis, excrucians, idahoensis, varipalpus,* and *canadensis* in the Northwest.



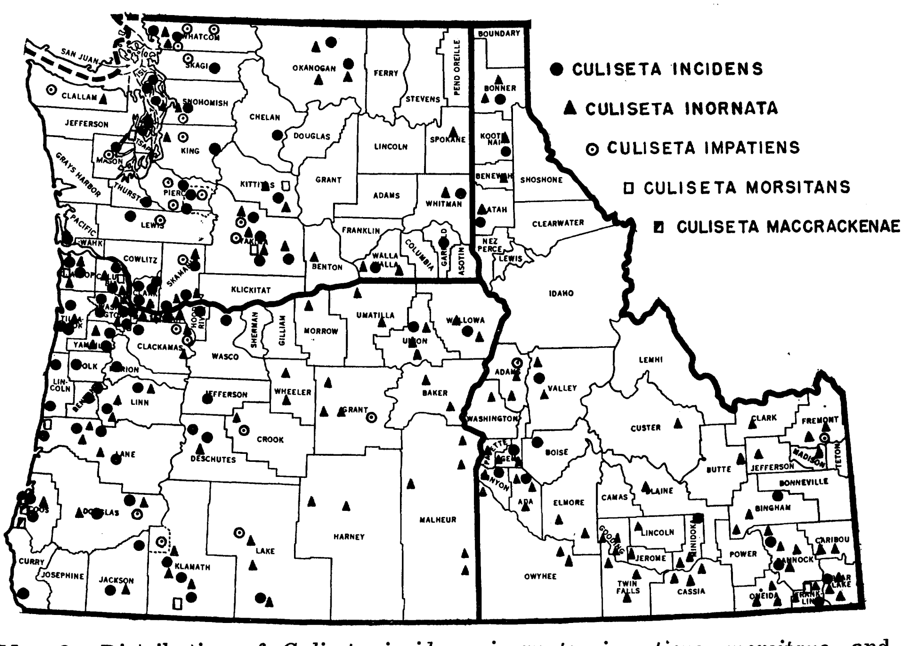
MAP 5.—Distribution of *Aedes increpitus, hexodontus, aboriginis,* and *flavescens* in the Northwest.



MAP 6.—Distribution of *Aedes ventrovittis, intrudens, cataphylla, trichurus, niphadopsis, impiger, pionips,* and *Mansonia perturbans* in the Northwest.



MAP 7.—Distribution of *Culex tarsalis, pipiens, territans,* and *stigmatosoma* in the Northwest.



MAP 8.—Distribution of *Culiseta incidens, inornata, impatiens, morsitans,* and *maccrackenae* in the Northwest.

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